TECHNOLOGY REVIEW

February 1952

TECHNOLOGY DEPT.

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DETROIT

Typical view showing Webster Walvector ® providing heat the full window length, column to column. The steam risers and the returns are in alternate columns. Webster Radiator Valves provide shut-off of the heat in each bay.

Steam Cost 12% under estimate

The Commerce Building, first new office building in Harrisburg since 1935, is obtaining Webster Tru-perimeter Heating results with Webster Moderator low-pressure steam heating, using 12% less steam than estimated.

The Pennsylvania Power & Light Co. estimated the cost of steam for heating at $3,527 per season. Meter readings for the first complete heating season showed steam cost of only $3,101, less by $426 than the estimate.

Architect William Lynch Murray specified a Webster Moderator System to assure "controlled-by-the-weather" economy in this 13-story building; Webster Walvector ® to spread the heat the full length of exposed walls.

Edward H. Bower, managing director and co-owner, says: "The continuous radiation beneath continuous window bands is just what we need. All sections of the building heat evenly, rapidly and comfortably regardless of outdoor weather conditions."

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SYSTEM

OF STEAM HEATING

"Controlled by the weather"

Commerce Building, Harrisburg, Pa. Architect: William Lynch Murray & Associates. Mechanical Engineer: Benj. A. Johnson. Heating Contractor: Herre Brothers.

Inset shows the heart of the Webster Moderator Control. Variator and Electronic Pressure Control Unit shown here operate in conjunction with the following equipment not shown: Outdoor Thermostat, motor-operated Main Steam Control Valve, and extended tube orifices installed in each Walvector ® unit.

All but one of the objects in this picture have something in common—Norton or Behr-Manning abrasive products are important factors in their manufacture and in their quality. *Can you find the stranger?*

The Submarine Truck? No! True, it's out of place in a swimming pool . . . but hundreds of its parts were produced with the help of Norton grinding wheels and machines and Behr-Manning abrasive products.

The Tile Floor? No! Both the curb and mosaic tiles are Norton floor products . . . unique because they are made non-slip, even when wet, by ALUNDUM abrasive. And, like many other tiles, they were fired in kilns lined with Norton refractories.

The Gasoline in the Pump? No! As it passed through the refinery on its journey from oil well to you, Norton high temperature refractories and catalyst supports were important quality factors.

The Football? No! Many vital operations in the manufacture of leather require Norton and Behr-Manning abrasive products. For instance, drums wound with Behr-Manning coated abrasives condition the grain before coloring – rough the surfaces for secure cementing.

The stranger in the picture is the cobweb. Remember, the manufacture of any man-made product. . . . whether of metal, wood, paper, cloth, leather, ceramics, or plastics . . . is dependent upon abrasives, abrasive products, refractories, or grinding machines that bear such well-known trade-marks as Norton and Behr-Manning . . . the world's largest manufacturers of abrasives and abrasive products.

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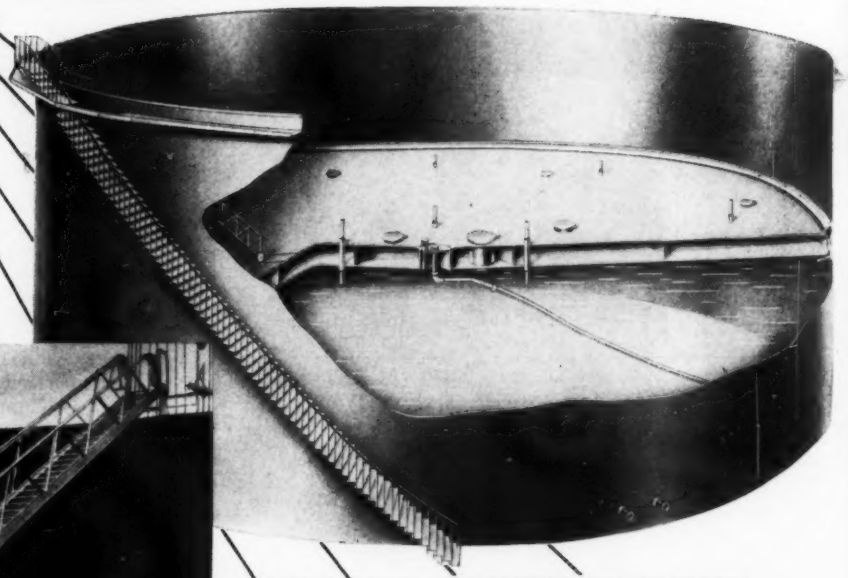

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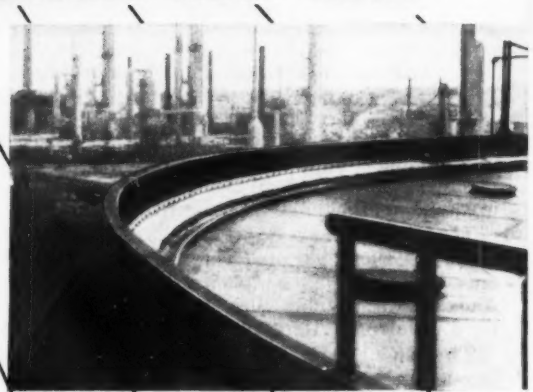

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A Steel Company now has a total of eleven VU Boilers in four different plants. Starting with three units in 1936, it has reordered three times . . . most recently in the fall of last year with an order for three more units.

A Textile Manufacturer ordered two VU Units in 1936. Another unit was installed in 1940 and a third in 1944. Still another textile company installed one unit in 1945, a second in 1949 and has just ordered another.

An Electric Utility Company installed its first VU Unit in 1941. Two more units were ordered for another plant in 1947, a unit for a third plant in 1946 and still another for a fourth station in 1949.

A Refining Company ordered one VU Unit in 1937, another in 1940 and another in 1949 for one of its plants; also two in 1942 and one in 1947 for another plant. B-486

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DIEFENDORF GEARS

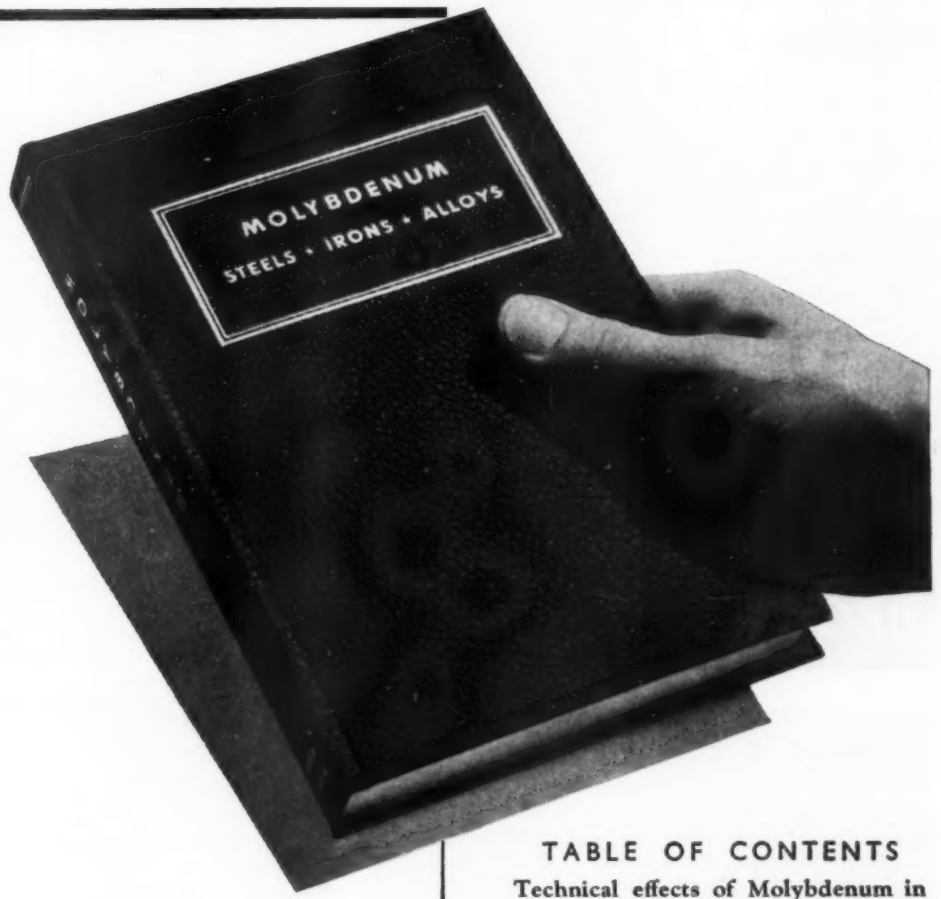
THE TABULAR VIEW

Pride of Independence.—In an era in which fiscal philosophy is all too commonly characterized by the search for gifts, it comes as a refreshing stimulant to be reminded that there are still hardy souls with sufficient pride and independence to finance their own collegiate education. For more than two decades the Technology Loan Fund, established through the foresight and able leadership of Gerard Swope, '95, has aided worthy students in financing their M.I.T. training. A statistical survey of the operations of this fund is given (page 181) by H. E. LOBDELL, '17, who has served as chairman of the Technology Loan Fund Board since its inception in 1930. As Dean of Students at M.I.T. and now as Executive Vice-president of the Alumni Association, Mr. Lobdell has had unique opportunities to witness the salutary effects of Technology Loan Fund operations. There is no way of assessing the character-building benefits of a program which stimulates self-reliance. But many of those who borrowed from T.L.F. for advancing their education now hold important positions of responsibility in industry, civilian government services, or the armed forces. This fact should be cause for gratification to all who have administered the fund.

In Short Supply.—With the nation's security dependent upon the most effective use of its limited resources of material and man power, PAUL COHEN, '35, offers a timely contribution (page 186) with his survey on the present shortage of engineers. As an editorial associate of The Review since 1938 and currently also engineer for the Sperry Gyroscope Company, Mr. Cohen is well acquainted with the problem and admirably equipped to discuss its seriousness. A substantial portion of Mr. Cohen's article deals with the role which American colleges can play in alleviating our present man-power deficiency through research. In this he makes extensive use of statistical studies supervised last summer at M.I.T. by John I. Mattill, Assistant Director, News Service.

Transport Helicopters.—The first of a two-part article on "The Significance of the Helicopter" by L. WELCH POGUE, appearing in the January issue of The Review, was devoted to a discussion of the versatility of the small helicopter. In this issue Dr. Pogue concludes his article (page 190) by outlining the present military uses and the anticipated commercial applications of transport helicopters designed to carry a load of as much as 10 tons. Prophecy is always likely to be dangerous, of course, but on the basis of the military uses of helicopters in Korea alone, there is every good reason to hope for early commercial service by transport helicopters. As this issue goes to press, Royal Air Force helicopters make the headlines as they stand by, on Britain's southwest coast, in readiness to rescue the skipper of the *Flying Enterprise*. Altogether, Dr. Pogue (whose biography appears on page 124 of the January issue) makes out a good case for the future of the helicopter.

For metallurgist and engineer . . .



This 400pp. book describes the varied applications of Molybdenum as an alloying element in a wide range of materials. It presents the fundamentals which must guide the selection of the most suitable alloys for specific applications.

Much recent information is included, some of it hard to find elsewhere. About 500 references to technical literature facilitate further reading, and there are 187 diagrams and 91 tables.

The book is available free on request by metallurgical and engineering students.

Climax Molybdenum Company
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Technical effects of Molybdenum in Steel, Cast Steel, Cast Iron.
Fundamental Effects of Heat Treatment on Microstructure.
Addition of Molybdenum.
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Wrought Corrosion Resistant Steels.
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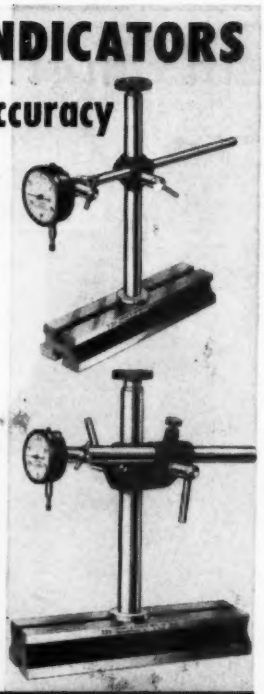

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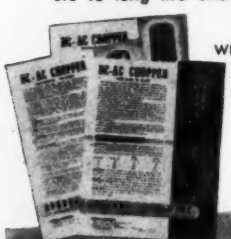

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MAIL RETURNS

Offbeat

FROM CLARK S. ROBINSON, '38:

I enjoyed the article by James L. G. FitzPatrick on "Some Thoughts on Natural Flight," in the November, 1951, Review. I would like, however, to call attention to an error on page 53. The frequency of wing beating is given as

$$F = 4W^{0.833}/M$$

and it is stated that W and M may be measured in any convenient units since they have the same dimensions. Actually the units do not cancel, since W is raised to the power 0.833. From the second formula Mr. FitzPatrick gives for F, it is evident that both W and M must be measured in pounds.
Champaign, Ill.

[The sentence is a carry-over from an early draft and should refer specifically to the first powers of the weight ratio mentioned. The formula shown is a shortened form of

$$F = 4W^{-1/6} \cdot W/M$$

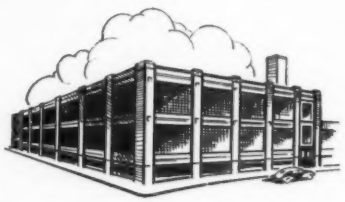
In his notes the author referred to W/M as the specific loading (L_s) and it is this alone which is dimensionless. If kilograms are substituted for pounds in the published form, the constant becomes approximately 4.8 – Ed.]

Precedent Broken

FROM FREDERICK BERNARD, '17:

I do not make a practice of writing to editors but wish to compliment you on the December, 1951, Review. All of the articles appealed to me as being of outstanding interest but I was particularly impressed with "The Lowell Institute School" by Arthur L. Townsend.

I would wager that most of our Alumni knew as little about the Lowell Institute as I did, which, in essence, was that it was a worthy project and that it was very generous of M.I.T. to let Lowell Institute use their plant facilities. I had no knowledge of the intimate relationship of the two institutions over a long period of years. It is true that M.I.T. does make a major contribution to the operation of Lowell Institute but in the early days it appears to have been a case of the tail wagging the dog.
Wellesley Hills, Mass.



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SENSITIVE . . . *but only to heat*

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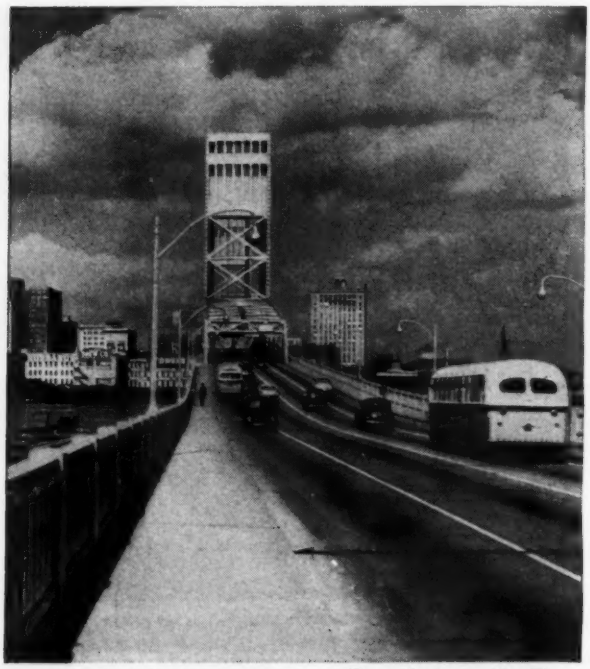

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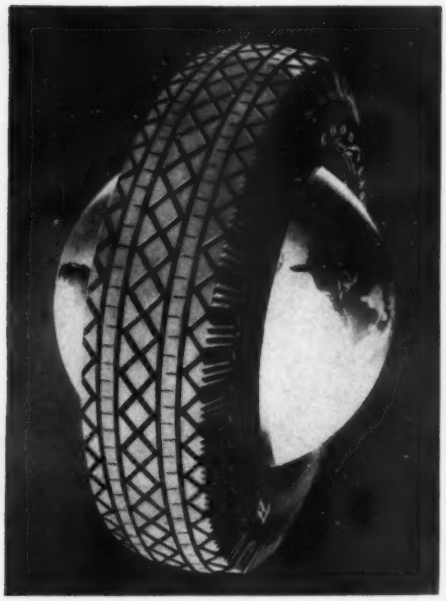

***remember*... more people ride on Goodyear tires than on any other kind**

GOODYEAR

Super-Cushion. T. M.—The Goodyear Tire & Rubber Company, Akron, Ohio

Photo by Ralph Morrissey from Black Star

"I don't see why I should take M22 when I'll never use differential equalitons."

THE TECHNOLOGY REVIEW

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Raymond E. Hanson

Surf at Ogunquit, Maine

THE
TECHNOLOGY REVIEW

Vol. 54, No. 4 February, 1952

The Trend of Affairs

Vigorous Hybrids

HYBRIDIZATION is a well-known method for breeding superior plants and animals. Broadly speaking, this procedure exploits "hybrid vigor." Such vigor may be explained on the basis that undesirable characteristics in general are recessive, and hence tend to disappear in hybrids of mixed ancestry but to show up in inbred strains of relatively pure ancestry. In practice, however, hybridization involves lengthy and tedious brother-sister matings over a period of years to produce uniform strains with stable inherited characteristics. Then follows the discarding of strains showing undesirable features. Next, the good strains are laboriously crossed (hybridized) to make a mixed strain having all of the desired characteristics and none of the bad ones. This procedure amounts to taking apart the heredity of the plant or animal, discarding the weak parts, and then reassembling the remainder. A terminal difficulty in hybridization results from the fact that hybrids do not breed true to type; hence, the several phases of hybridization must be repeated every time a new generation is to be produced.

A simplified account of the prototype of successful hybridization, hybrid corn, will perhaps serve to make tangible the foregoing somewhat abstract description.

After years of inbreeding by fertilizing plants with their own pollen, the necessary genetically stable strains of corn were produced. For purposes of illustration, let us say that these comprised four different corn types possessing, respectively, a strong stalk, a tall stalk, large ears, and the desired kernel. Each of these pure strains totally lacked the other three desired features. At the outset, the strong-stalk variety was crossed with the one having tall stalks, to make a corn with tall, sturdy stalks. At the same time, the large-ear type was hybridized with the corn having superior kernels, thus effectuating a combination of these two features. Finally, to make each year's crop of seed, the two foundation corns were crossed. The resultant hybrid corn was thus a resynthesis of everything corn should be.*

The advantages of hybridization, proven with corn, have been steadily extended to other plant crops including wheat, and then to domestic animals, such as the chicken. But now comes the surprising announcement that superior forest trees are being developed by hybridization. This turn is unexpected because forestry is one field where nature has usually been allowed to take its course. Reseeding after lumbering has usually been accomplished by merely leaving uncut a few of the original trees. Or even when seedling trees have been raised in nurseries, seed from wild trees has been used.

But now researchers in the United States Department of Agriculture are applying the proven principles of plant hybridization to pine trees. They assert that their work is in its early stages, and that disappointments and reverses, such as beset the early years of hybrid corn, may be expected. Nevertheless, a pine has been developed that, when a few years old, is twice as tall and several times as heavy as the better of its two parent strains at the same age. Such quick growth is a prime advantage for trees, provided there is no compensating loss as in timber quality or disease resistance.

Trees grown on wood lots, and sold for paper-pulp production, have for some time been a good cash crop for farmers, especially in the warmer parts of this country. Although as much as two decades may elapse before the work on tree hybridization can be completed, trees that can treble the timber output from a given area promise future added impetus to wood-lot tree raising, as well as to the controlled reseeding of denuded forest areas.

*For a more detailed account of hybrid corn, with some interesting side lights, see "Ideal By-Product," The Technology Review, 50:23 (November, 1947).

Simplest Atom Discovered

THE positron, or positive electron, is an "elementary" particle first observed in 1932 by Carl D. Anderson. Ample theoretical evidence is at hand to indicate that the mass of the positron is the same as that of the common negative electron or negatron, and within the limits of experimental error, this conclusion is substantiated by experiment. Both particles may be thought of as spinning on their axes.

According to theory advanced by P. A. M. Dirac, the positron bears an intimate relation to the negatron, somewhat like that which exists between an air bubble in water and a water droplet (of the same size) in air. Just as the droplet can fill the bubble, so can a positron and a negatron "annihilate" each other. In the process of such annihilation, the energy, represented by the masses of the two elementary particles, appears as electromagnetic radiation, usually in the form of two rays or quanta of equal energy which are emitted in opposite directions. Such theoretical predictions are completely borne out by experiment. The importance of these discoveries to atomic physics was recognized by the awards of Nobel prizes to both Anderson and Dirac.

Because these particles are rarely found in nature, the properties of positrons are not easily studied in the laboratory. Theoretically, the average lifetime of a positron in solid materials is predicted to be about 10^{-10} second; in gases at ordinary pressures the lifetime is extended to about 10^{-7} second. The latter figure was first verified experimentally in 1949 in the Institute's Laboratory for Nuclear Science and Engineering by Professor Martin Deutsch, '37, and James W. Shearer, 6-45, of the Department of Physics. Positrons can be observed only during a brief time interval after their creation in some nuclear or other high energy process. Nevertheless, it has long been considered very desirable to investigate, as thoroughly as possible, the forces acting between positrons and negatrons, because detailed knowledge of the forces between such particles is closely linked with our basic concepts concerning the nature of electrons and the electromagnetic field.

In the past, the forces between positrons and electrons have been investigated by letting a stream of positrons impinge on a thin foil and observing the angular distribution of the particles scattered by such impact. A statistical analysis of a very large number of encounters is required to get even moderate accuracy in determining the forces involved.

Much better precision can be obtained when the two particles describe closed orbits and form a bound system. Basic principles of atomic physics tell us that the orbits of the particles will be exactly the same every time such a structure is formed. At most, the system may exist in a few easily distinguishable modifications. The orbits and all other properties of such bound systems or atoms can be calculated with great accuracy when the forces are known. The calculations can then be accurately tested by experiment. The best known bound systems of this kind are hydrogen atoms.

Since the positron has the same charge as a hydrogen nucleus it should be able to combine with an electron to form a system very much like a hydrogen atom. This was first pointed out in 1936 by E. Ruark, who proposed the name "positronium" for this hypothetical atom. Considerable theoretical work was done on the expected properties of positronium by a number of American, French, Russian, Norwegian and Swedish authors, but unitl recently no experimental evidence for its existence had been found.

During the last few months, this elusive atom has been found experimentally, and its properties have been studied by Professor Deutsch and Everett P. Dulit, '50, in the Department of Physics. Positronium is formed whenever positrons are stopped in any gas. Positronium can be formed in two modifications. The para-positronium form, in which the two spins are opposed, lasts only 10^{-10} second but the ortho-positronium, in which the two spins are parallel, survives for about 10^{-7} second. At M.I.T. the lifetime of the ortho-positronium was measured directly by electronic means and the results gave a clear agreement with theoretical results.

The second important property of positronium, which has been studied at M.I.T., concerns the behavior of this atom in a magnetic field. Theoretical considerations show that ortho-positronium should be converted to para-positronium by a strong magnetic field. The rate of conversion is a sensitive test of the forces acting between the particles at short distances. The large electromagnet, designed by Professor Francis Bitter, was used to perform these experiments, and the conversion was detected by observing the change in wavelengths of the emitted gamma rays. The results show very clearly the existence of a force, predicted by Dirac's theory, which would not be present if electron and positron were unrelated particles.

Properties of Refractories

NEW experimental data recently obtained at the Institute add to the storehouse of knowledge regarding the thermal properties of certain refractory materials. In a program of research sponsored by the Atomic Energy Commission and conducted by Frederick H. Norton, '18, Professor of Ceramics, and William D. Kingery, '48, Assistant Professor of Ceramics in the Department of Metallurgy, values of thermal conductivity of beryllia (BeO), mullite ($3Al_2O_3.2SiO_2$) and zirconia (ZrO_2), and other refractory oxides have been measured for temperatures up to 1,300 degrees. A few preliminary values of thermal conductivity have also been determined for temperatures as high as 1,800 degrees C. In addition, values of the thermal conductivity of Al_2O_3 and MgO, and others have been determined from room temperatures to 500 degrees C.

The effect of porosity on thermal conductivity is a major problem requiring solution before the data on thermal conductivity of pure materials can be applied to manufactured refractories. The development of a theory of the effect of pores and porosity on thermal conductivity that is amenable to experimental verification has been completed by Arthur L. Loeb of the Institute's Division of Industrial Cooperation, as the initial phase of this problem.

T.L.F. Survey

An Assessment of the Results of the First 21 Years of the Technology Loan Fund, Made with the Co-operation of 1,799 Alumni Who Borrowed and Repaid a Total of $1,175,644

By H. E. LOBDELL

DURING the booming latter 1920's, with a prescience that, in retrospect, appears to have been truly remarkable, Gerard Swope, '95, persuaded 17 others to join him in making possible a test of a pioneer idea in educational financing. It was his feeling that an institution such as M.I.T. might continue to meet its future capital needs for buildings and equipment from gifts and bequests, but it properly should expect students to pay a tuition fee more nearly commensurate with the cost of their education to provide for ever-mounting operating needs, especially for Faculty and staff salaries.

At that time, the Institute's direct annual cost of instruction was estimated as being between $700 and $900 per student, and its annual tuition fee, which for some time had been $400, was about to be raised to $500 as of 1931–1932. But, as Dr. Swope pointed out, "to increase tuition without at the same time making provision for students who have not sufficient means to take advantage of the education offered by the Institute, would be tragic."

Such provisions could be made through adding to the existing scholarship funds, he recognized. But since only the income thereof would be available annually for student aid, a large amount of additional capital would be required to meet the situation effectively by this method. If, however, the same amount of additional capital were used to establish a loan fund, both principal and its income would be available immediately for the benefit of students.

Moreover, awards from the annual income of scholarship funds were granted customarily as outright gifts, and hence any further building up of the Institute's resources for aiding students by this method, as time went on, could not be accomplished through reliance upon anticipated reimbursements from past beneficiaries. By contrast, the recipient of an award from a loan fund assumed a definite obligation to repay his borrowings with interest, for, in effect, he was simply postponing his own payment for his education from the student period, when his earning capacity was low, to a later period when, as an alumnus it would be higher.

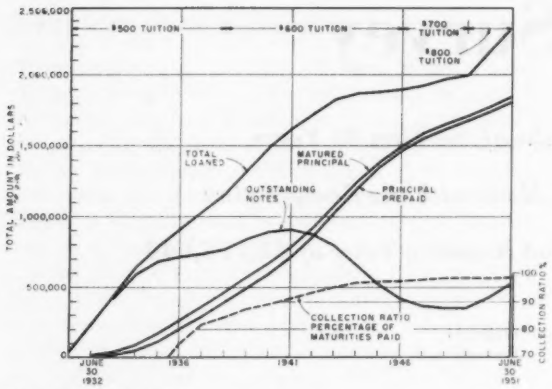
Dr. Swope, therefore, advocated the creation of a large loan fund to which any M.I.T. student in good academic standing would be eligible to apply for loans equivalent to three years' tuition, or four years' if he continued for graduate work. Loans were to bear interest at 2 per cent from the time negotiated, and repayments on principal were to be scheduled at a rate of $50 every six months following the expected date of graduation.

This proposal called for making loans to students on a scale hitherto unprecedented in educational circles. To implement the idea, subscriptions totaling $4,200,000 and payable over a 10-year period were underwritten by Dr. Swope himself, aided by William E. Nickerson, '76, Coleman du Pont, '84, Charles A. Stone, '88, Edwin S. Webster, '88, Frank L. Dame, '89, Pierre S. du Pont, '90, Charles Hayden, '90, Charles Neave, '90, Albert G. Davis, '93, Frank W. Lovejoy, '94, Alfred P. Sloan, Jr., '95, Franklin A. Park, '95, Irenee du Pont, '97, William C. Potter, '97, Lammot du Pont, '01, John E. Aldred, and George Eastman. In addition to these underwriters, further contributions to the fund were made by Harry J. Carlson, '92; William R. Kales, '92; Eugene H. Clapp, '95; Edward L. Hurd, '95; William Endicott, and W. Cameron Forbes.

Thus the Technology Loan Fund – the "T.L.F." for short – came into operation in the autumn of 1930, responsibility for receiving applications and approving loans being entrusted to a Loan Board composed of Karl T. Compton, then President of M.I.T., now chairman of the Corporation; Horace S. Ford, then Bursar of M.I.T., and Treasurer from 1934–1950; James L. Tryon, Director of Admissions at M.I.T., 1930–1936; Delbert L. Rhind, then Assistant Bursar and now Bursar of M.I.T.; and H. E. Lobdell, '17, then Dean of Students and now Executive Vice-president of the Alumni Association – the latter two being designated as secretary and chairman, respectively.*

During the initial year of 1930–1931, loans amounting to $54,000 were made to 222 men; and by the end of three years (1930–1934), the corresponding cumulative totals were $640,000 and 1,173. Also by then, repayments on principal had amounted to $52,000 and $16,683 of interest had been collected.

* Dr. Tryon served until 1936, Dr. Compton until 1949, and Mr. Ford until 1950. Their successors and others have served on the Loan Board as follows, the names being arranged in the chronological order of appointment: Professor B. Alden Thresher, '20, Director of Admissions (1936-1950); Thomas P. Pitré, Dean of Freshmen (1947-); Everett M. Baker, Dean of Students (1947-1950); James R. Killian, Jr., '26, President of M.I.T. (1949-1950); Professor Julius A. Stratton, '23, Provost (1950-); Joseph J. Snyder, 2-44, Treasurer (1950-); Professor John T. Rule, '21, in charge of the Section of Graphics and Course IX (1950-).



M.I.T. Illustration Service

CHART A — *Record of Annual Transactions of Technology Loan Fund*

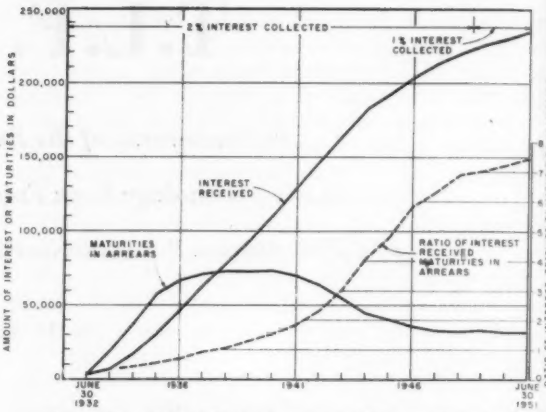


CHART B — *Maturities in Arrears and Interest Received*

In view of this early operating experience, it was felt that the $1,451,000 already paid in by the 18 underwriting subscribers and six contributors gave the T.L.F. sufficient working capital for the time being; and therefore these Alumni and friends of the Institute, who had brought the T.L.F. into being, were released from their remaining pledges. At this point it is apposite to note that, by the T.L.F.'s own operations, the original capital of $1,451,000 has since grown nearly 50 per cent, to $2,151,191.

During the first 21 years, ending June 30, 1951, loans totaled $2,341,517; and repayments on principal totaled $1,811,806 — or 98.2 per cent of the amount then due to be repaid. The year-by-year record of these transactions is illustrated graphically in Chart A.

As shown in Chart B, on June 30, 1951, the $31,478 of "maturities in arrears" included $9,344 which had been "written off" (mostly accounts of deceased borrowers), and payments on notes totaling $22,134 had been postponed. As an offset to the $31,478 of maturities unpaid, interest received by the Fund up to June 30, 1951, totaled $234,184. Thus, as shown in Chart B, by 1938 cumulative interest received more than balanced maturities then unpaid; and interest received up to 1948 provided a coverage of over six times potential losses. Consequently, beginning with January 1, 1949, the Loan Board decided to waive the collection of interest above 1 per cent, the previous rate having been 2 per cent.

Chart C, which indicates the year-by-year rise in the number of individuals aided to 3,215, also shows the rise in the number who have completely discharged all their financial obligations toward the T.L.F. — to a total number of 2,319 as of June 30, 1951. It was to this latter group that the Board turned last autumn for data upon which to assess the results of the T.L.F. since its establishment in 1930, measured in values inexpressible through the Board's accounting figures.

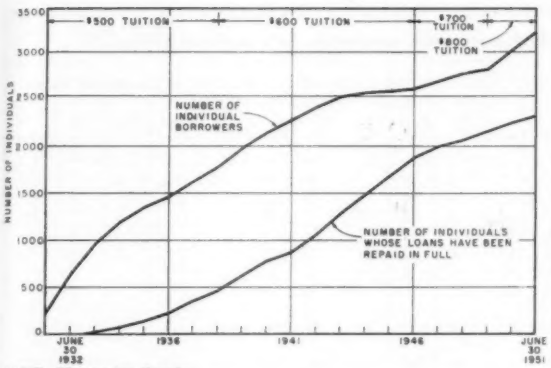
Of the 2,319 who had fully repaid their loans, 80 were deceased, and adequate current addresses were lacking for 81. Inquiries were directed to the remaining 2,158, seeking up-to-date information as to positions held and present salary ranges (for statistical purposes only), as well as about noteworthy medals, awards, or other honors achieved since leaving the Institute. By mid-December, completed data cards were returned by 1,799, or nearly 84 per cent of those queried; and of these 1,799, 1,738, or nearly 97 per cent, recorded a salary range.

The 2,319 were invited to supplement return of the above-mentioned data by giving "any reflections . . . as to the Institute's policy in respect to maintaining the Fund," and by expressing any opinions they held as to how its operation might be improved. As a consequence, data cards returned by 249, or nearly 14 per cent of the 1,799, were accompanied by messages or letters, many of which contained constructive suggestions greatly appreciated by the Loan Board. It is to be regretted that space limitations preclude quotation herein from these interesting and encouraging communications, which indicated in no uncertain terms that the overwhelming majority of those writing look back with unusual satisfaction upon having in part financed their education through the T.L.F. Only five of the 249 took occasion to complain about the Board's operating methods: three as to how loans were made, and two as to methods of making collections.

Inasmuch as nearly 39 per cent of the 1,799 answering the query saw service in the armed forces during World War II, it is not surprising that 64 decorations arising from such service were reported. The 59 given by the United States were: Silver Star, 1; Legion of Merit, 13; Distinguished Flying Cross, 3; Bronze Star, 22; Air Medal, 4; and Commendation Ribbon, 16. The five given by foreign governments were: a British Distinguished Flying Cross and an O.B.E.; an Italian Medal for Valor and a Knight Officer Cross of the Order of the Crown of Italy; and a Haitian *Légion d'honneur*.

Further decorations arising from civilian war service numbered 14, including: Medal for Merit, two; Medal of Freedom, two; Presidential Certificate of Merit, two; other awards or commendations by American military or naval authorities, seven; and to one man, His Britannic Majesty's Medal for Service in the Cause of Freedom.

But the 42 notable postwar distinctions are as impressive as the 78 mentioned above, namely: honorary doctorates have been conferred on three men (two in



M.I.T. Illustration Service

CHART C — *Number of Individuals Aided by Technology Loan Fund*

Engineering and an LL.D.); nine have won fellowships (including two Guggenheims, two National Research, and a Fulbright); four have been signally honored by industry (including a Vail Medal and a Coffin Award); three "development" awards from the Navy are reported; three men have been cited for exceptional or superior service (by the Departments of State, Commerce, and Agriculture); two have been Rhodes Scholars; and on one man Bolivia has bestowed its Grand Cross of the Condor of the Andes. Moreover, although less than 1 per cent of the 1,799 are more than 20 years out of the Institute, 17 have been honored publicly already by scientific and professional bodies. This group of 17 includes medalists of the American Society for Metals (the Henry Marion Howe ['71] Medal), American Society of Civil Engineers (Rickey), American Foundrymen's Society (Simpson), Engineering Institute of Canada (Lionard), Franklin Institute (Longstreth), Boston Society of Civil Engineers (Desmond Fitzgerald); and a recipient of the Swedish King Gustav V Gold Medal for Architecture.

Geographically by census divisions, the Middle Atlantic leads with 557, or 31 per cent of the 1,799. New England has 546, or 30.6 per cent; North Central, 226, or 12.5 per cent; South Atlantic, 192, or 10.6 per cent; Pacific, 125, or 6.9 per cent; South Central, 104, or 5.8 per cent; and Mountain, 30, or 1.6 per cent. The remaining 19, or 1 per cent, comprise 10 in Canada and 9 overseas: 4 in U.S. Territories, and one each in Bermuda, England, Guatemala, Holland, and Lebanon.

By states, Massachusetts with 415, or 23 per cent of the 1,799, is first. Next to Massachusetts, the 10 leading states are: New York with 269, or 15 per cent; New Jersey, 161, or 9 per cent; Pennsylvania, 127, or 7 per cent; California, 96, or 5.3 per cent; Connecticut, 82, or 4.6 per cent; Ohio, 69, or 3.8 per cent; Illinois, 59, or 3.3 per cent; Maryland, 54, or 3 per cent; Texas and Virginia, each with 46, or 2.6 per cent. Three states — Idaho, Nebraska, and North Dakota — have only one of the 1,799; and 3 others — Nevada, South Dakota, and Wyoming — have none.

The distribution of the 1,799 according to highest M.I.T. degree attained, and showing the amounts borrowed and repaid, follows as Table I:

Table I — Over-all statistics of Technology Loan Fund

M.I.T. degree status	*Number*	*Percentage*	*Total amount borrowed and repaid*	*Average per capita loan*
No degree	118	6.6	$ 47,013	$398
Bachelor's	1,059	58.8	$ 751,241	$709
Master's	476	26.5	$ 294,732	$620
Doctorates	146	8.1	$ 82,658	$566
Totals	1,799	100.0	$1,175,644	$654

The distribution of the 1,738, who recorded a salary range (96.6 per cent of the 1,799), according to the number of years of experience, follows as Table II.

Table II — Median salary according to experience

Years out	*Number*	*Percentage*	*Median salary range*
Over 15*	806	46.4	$9,000–$12,000
10 to 15	525	30.2	$7,500–$ 9,000
5 to 10	298	17.1	$6,000–$ 7,500
5 or less	109	6.3	$4,500–$ 6,000
Totals	1,738	100.0	$7,500–$ 9,000

*Less than one per cent out more than 20 years.

The distribution of these 1,738 according to salary ranges follows as Table III, and for convenience of reference the percentages below and above the median salary range ($7,500–$9,000) of the entire group of 1,738 are shown for each subdivision:

Table III — Salary distribution of TLF borrowers

Salary Range	*No degree*	*Bachelors*	*Masters*	*Doctors*	*Totals*	*Percentages*
Under $4,500	8	35	9	1	53	3.1
$4,500–$6,000	22	133	55	7	217	12.5
$6,000–$7,500	18	250	82	31	381	21.9
$7,500–$9,000	23	234	117	33	407	23.4
$9,000–$12,000	22	204	98	42	366	21.0
$12,000–$15,000	10	85	52	14	161	9.3
Over $15,000	10	84	49	10	153	8.8
Totals	113	1,025	462	138	1,738	100.0
Percentages:						
Below $7,500	43	41	32	28	38	
Above $9,000	37	36	43	48	39	

A detailed breakdown of the data presented in Tables II and III appears in Table IV, on the basis of which it is possible to make certain comparisons qualitatively with data given in the "1950 Annual Survey of Professional Scientific Salaries," issued by the Personnel Department of the Los Alamos Scientific Laboratory in New Mexico. The Los Alamos studies, in which a total of 182 organizations participated, embrace average salaries for 27,273 professional scientific personnel employed in 232 individual research and development laboratories operated by private industrial concerns, government departments and agencies, Atomic Energy Commission contractors, research institutes, and private consulting firms.

In the Los Alamos studies no distinction is made between men with the bachelor's and master's de-

Table IV — Distribution of salary ranges of 1,738 TLF borrowers according to years out of M.I.T.

Salary Range	Over 15 Years Out					10 to 15 Years Out					5 to 10 Years Out					Out 5 Years or Less				
	No degree	Bachelors	Masters	Doctors	Totals	No degree	Bachelors	Masters	Doctors	Totals	No degree	Bachelors	Masters	Doctors	Totals	No degree	Bachelors	Masters	Doctors	Totals
Under $4,500	3	7	1	..	11	1	4	2	..	7	2	9	2	1	14	2	15	4	..	21
$4,500–$6,000	11	41	18	..	70	2	28	10	1	41	6	34	15	3	58	3	30	12	3	48
$6,000–$7,500	6	94	28	8	136	10	83	19	7	119	2	62	29	9	102	..	11	6	7	24
$7,500–$9,000	14	118	45	2	179	6	91	49	14	160	3	24	23	12	62	..	1	..	5	6
$9,000–$12,000	14	115	59	12	200	4	69	26	18	117	4	19	10	8	41	..	1	3	4	8
$12,000–$15,000	4	58	28	4	94	5	19	20	8	52	1	6	4	2	13	..	2	..	..	2
Over $15,000	8	69	34	5	116	2	10	13	4	29	..	5	2	1	8	..	..	..	..	..
Totals	60	502	213	31	806	30	304	139	52	525	18	159	85	36	298	5	60	25	19	109
Percentages:																				
Below $7,500	33	28	22	26	27	43	38	22	15	32	56	66	54	36	58	100	93	88	53	85
Above $9,000	43	48	57	68	51	37	32	43	58	38	28	19	19	31	21	..	5	12	21	9

Table V — Comparisons of salary ranges of TLF borrowers and average salaries for scientific personnel

Years out	Bachelors and Masters		Doctors	
	Median Range for M.I.T.	*Los Alamos averages*	*Median Range for M.I.T.*	*Los Alamos averages*
Over 15	$9,000–$12,000	.....	$9,000–$12,000	.....
16 and 20	.....	$6,408–$7,092	.....	$7,596–$8,232
10 to 15	$7,500–$9,000	.....	$9,000–$12,000	.....
11 and 15	.....	$5,796–$6,348	.....	$6,816–$7,500
5 to 10	$6,000–$7,500	.....	$7,500–$9,000	.....
6 and 10	.....	$4,728–$5,640	.....	$5,504–$6,564
5 or less	$4,500–$6,000	.....	$6,000–$7,500	.....
5	.....	$4,488	.....	$5,520

grees, and hence the data shown for these two groups in Table IV have been combined for the purposes of Table V which appears above.

Tables VI and VII, which appear on page 185, show the distribution of the 1,025 bachelors who recorded a salary range (1) according to their undergraduate courses, and (2) by census divisions. These data seem to suggest that one derives comparative financial advantages from having pursued Courses XV, XVI, or III; and from having located in the Middle Atlantic, North Central, or South Central census divisions. (At the risk of redundancy be it noted that the South Central census division includes the sovereign state of Texas.)

According to "What They Do," the 1,799 may be grouped conveniently under 17 main headings, seven of these being nonindustrial and 10 industrial. Included under the first seven nonindustrial headings are 739, or 41.1 per cent of the 1,799, distributed as follows:

1. **Education,** 120 (6.7 per cent of the 1,799):
   - 110 hold professorial rank or instructorships in 56 universities, including 30 on the staff of M.I.T. Of these 110, 7 are department heads, 17 full professors, 32 associate professors, and 29 assistant professors.
   - 10 are in secondary school teaching.

2. **National Military Establishment,** 118 (6.5 per cent):
   - 47 of commissioned rank: 20 in the Army, 14 in the Navy, 11 in the Air Force, and 2 in the Marines. Of these 47, 3 are colonels, 19 lieutenant-colonels or commanders, 11 majors or lieutenant commanders, 10 captains or lieutenants, 1 first lieutenant, 1 lieutenant (junior grade), and 2 second lieutenants.
   - 41 in civilian capacities with the Department of the Navy, including: Bureau of Ordnance, 9; Office of Naval Research, 7.
   - 23 in civilian capacities with the Department of the Army, including: Ordnance Department, 5.
   - 7 in civilian capacities with the Department of the Air Force.

3. **Others With Government,** 89 (5.0 per cent):
   - 67 in the services of the United States, including: Atomic Energy Commission, 13; Weather Bureau, 8; National Advisory Committee for Aeronautics, 6; Geological Survey, 6; Public Health Service, 5; Bureau of Standards, 5.
   - 22 in the service of states and municipalities.

4. **Self-Employed,** 119 (6.6 per cent):
   - 47 owners or partners in businesses; 26 architects; 17 consulting engineers; 9 practicing physicians.

5. **Employed Professionally,** 189 (10.5 per cent)
   - 82 by consulting or management firms, including: Jackson and Moreland, 9; Arthur D. Little, Inc., 6.
   - 22 by architects.
   - 85 in research laboratories, including: M.I.T. Division of Industrial Coöperation, 20; those of other educational institutions or foundations, 18.

6. **Mercantile,** 20 (1.1 per cent)

7. **Unclassified,** 84 (4.7 per cent)
   - including, editors or writers, 8; banking and finance, 6; graduate students, 6; agriculture, 5;

Table VI — Salary range distribution of 1,025 bachelors according to their undergraduate courses

Salary Range	*Electrical Eng.*	*Eng. Admin.*	*Chem. Eng.*	*Mech. Eng.*	*Aero. Eng.*	*Civil Eng.*	*Physics*	*Metallurgy*	*Naval Arch.*	*Other Courses*	*Totals*
Under $4,500	6	6	3	2	4	1	1	..	1	11	35
$4,500–$6,000	15	12	27	13	7	9	10	6	3	31	133
$6,000–$7,500	40	21	33	29	15	23	15	13	15	46	250
$7,500–$9,000	38	37	19	28	20	15	8	4	8	57	234
$9,000–$12,000	25	27	21	28	29	10	10	17	6	31	204
$12,000–$15,000	8	17	9	9	10	7	6	2	5	12	85
Over $15,000	11	20	12	5	3	8	4	3	3	15	84
Totals	143	140	124	114	88	73	54	45	41	203	1,025
Percentages:											
Below $7,500	43	28	51	39	30	45	48	42	46	43	41
Above $9,000	31	46	34	37	48	34	37	49	34	29	36

Table VII — Salary range distribution of 1,025 bachelors according to census divisions

Salary Range	*New England*	*Mid Atlantic*	*North Central*	*South Atlantic*	*Pacific*	*South Central*	*Mountain*	*Others**	*Totals*
Under $4,500	18	8	3	2	..	2	..	2	35
$4,500–$6,000	58	26	12	14	14	4	4	1	133
$6,000–$7,500	100	62	30	25	14	11	7	1	250
$7,500–$9,000	70	83	26	25	16	11	1	2	234
$9,000–$12,000	56	66	30	25	10	11	3	3	204
$12,000–$15,000	19	42	11	4	7	2	..	..	85
Over $15,000	23	27	14	3	5	10	1	1	84
Totals	344	314	126	98	66	51	16	10	1,025
Percentages:									
Below $7,500	51	31	36	42	42	33	69	40	41
Above $9,000	29	43	44	33	33	45	25	40	36

*2 in Canada and 8 overseas: 3 in U. S. Territories and one each in Bermuda, England, Guatemala, Holland, and Lebanon.

clergy, 3; members of Parliaments, 2; a Group Captain in the Royal Canadian Air Force;—and the one man of the 1,799 who declares himself already to have "retired."

Included under the 10 industrial headings are 1,060, or 58.9 per cent of the 1,799, distributed as follows:

8. **Manufacturers of Equipment, Apparatus, or Instruments,** 223 (12.4 per cent of the 1,799):
   including, General Electric, 48; Western Electric, 10; Westinghouse, 10; United Shoe, 9; American Brake Shoe, 8; M. W. Kellogg, 8; Sperry, 8; General Radio, 5; Babcock and Wilcox, 4; I.B.M., 4.

9. **Chemicals,** 197 (11.0 per cent):
   including: Du Pont, 44; Union Carbide, 18; Eastman, 16; American Cyanamid, 12; Dewey and Almy, 7; Monsanto, 6; Rohm and Haas, 6; Hercules, 5.

10. **Aircraft,** 86 (4.8 per cent):
    including: Bell, 8; Boeing, 8; United Aircraft, 8; Bendix Aviation, 5; Grumman, 5; Lockheed, 5; Martin, 5; North American, 5; Consolidated Vultee, 4; Curtiss Wright, 4; Hughes, 4; Northrup, 4.

11. **Electronics,** 76 (4.2 per cent):
    including: Raytheon, 21; R.C.A., 9; Sylvania, 7; Philco, 4.

12. **Petroleum,** 76 (4.2 per cent):
    including: Standard Oil of New Jersey, 10; Socony-Vacuum, 9; Shell, 8; Standard Oil Development, 8; Standard Oil of Indiana, 7; Atlantic, 5; Magnolia, 4; Standard Oil of California, 4; Texas, 4.

13. **Non-Ferrous Materials,** 63 (3.6 per cent):
    including: National Lead, 5; Johns-Manville, 4.

14. **Construction,** 55 (3.0 per cent)

15. **Utilities,** 47 (2.6 per cent):
    including: American Telephone and Telegraph, 6; others with the Bell System, 10.

16. **Ferrous Materials,** 44 (2.4 per cent):
    including: Bethlehem, 9; U. S. Steel, 8.

17. **Miscellaneous,** 193 (10.7 per cent)
    including: insurance, 25; textiles, 23; shipbuilding, 20; rubber, 22 (including 6 with Goodyear); transportation, 21; paper and pulp, 19; food and beverages, 13; automotive, 13 (including 5 with General Motors and 4 with Ford); soap, 9 (including 5 with Procter and Gamble and 4 with Lever); mining and smelting, 8; leather, 5.

It is of particular interest to observe that of the 1,060 men in Industry 65 are presidents, 50 vice-presidents, 11 treasurers or comptrollers, 17 general managers, 42 directors of research or development, and 89 chief engineers, chemists, or metallurgists—totaling 274. In addition to these 274, there are 221 other executives reporting salary ranges of $9,000 and upwards (including 58 in the $12,000–$15,000 range, and 49 in the $15,000 and over range). Thus, one may reasonably conclude that at least 495, or 46.7 per cent of the 1,060 in Industry, are now occupying responsible posts in the field of industrial management.

The Shortage of Engineers

If Our Present Military and Civilian Needs Are To Be Met, Demands for Technically Trained Man Power Will Continue To Exceed the Available Supply for Several Years

By PAUL COHEN

Of the various shortages currently facing the American economy, none is potentially more serious than the scarcity of engineers. In this, the most rapidly growing profession in the nation, the present deficiency is estimated to be as high as 60,000. Moreover, it is virtually certain that the number of graduates leaving the engineering colleges during the next few years will be appreciably smaller than the demand. But such a seller's market has not always existed in engineering, nor was our society as technologically minded as it is today.

In 1900, this country possessed less than 40,000 engineers, or approximately one for every 250 industrial workers. At the turn of the century, when the nation's population was about 76,000,000, only about 8,500 were members of the major engineering societies. In 1940, when there were about 250,000 engineers in the country, or about one engineer to every 80 industrial workers, the membership in engineering societies had risen to slightly more than 80,000 and the national population was 132,000,000. Today, with a population of 152,000,000, there are about 400,000 engineers in the country, not including 175,000 scientists, and the number of industrial workers per engineer has dropped to about 60. This, then, indicates the past growth of the engineering profession, but it does not necessarily indicate future trends.

If we are to maintain our present engineering population, 7,500 engineering graduates are needed annually to replace those lost by death or retirement, according to the Bureau of Labor Statistics, and 9,000 replacements may be needed by the end of the decade. In addition, many thousands more are needed to replace those engineers who shift to other fields of work. It seems reasonable, therefore, to believe the above figures should be at least doubled if we are merely to maintain the *status quo*. But our society does not stand still; it is becoming ever more technological, and consequently requires increasing numbers of engineers even in time of peace. If provision is made for the addition of another 100,000 engineers to the profession over the next 12 years, it appears that, even in a strictly peacetime economy, some 20,000 new engineers could be absorbed annually. The impact of the rearmament program must also be taken into account, however, and when this is done, it appears that there is good need – and certainly room – for some 30,000 engineering graduates per year. On the basis of present enrollment and any future conditions we are able to predict with reasonable accuracy, we shall fail to achieve that training objective by a very sizable margin.

The long-term trends that have created and nourished our present shortage of engineering personnel are: (1) a massive acceleration in the pace of research, both civilian and governmental, and (2) a continuing increase in the size and complexity of the nation's productive plant. Under normal circumstances, the increased demands for technical personnel to meet these needs might have been met by a corresponding natural growth in engineering education. A serious interruption in the normal flow of engineering graduates during World War II was an exceedingly important factor contributing to the present shortage. The straw that broke the camel's back, however, was the heavy defense effort that started with the outbreak of aggression in Korea. Since mid-1950, the shortage of engineers has been pronounced, and in a few fields, it has approached hysteria.

From 1942 to 1945, engineering training for able-bodied males virtually ceased in the United States. Even during a period of war, the policy of staying technical education in a country as highly industrialized as the United States had its drawbacks, but the long-term effects were truly serious. Not all countries shared our cavalier attitude toward the importance of the engineering profession during these trying years, however. Immediately after the end of World War II, there was a tremendous influx of veterans into the engineering schools, with the peak reached in 1946 when 91,000 freshmen enrolled as engineers. Since then, the size of freshman classes has been dropping steadily, with an anticipated drop in number of graduates four years later, as shown in the following table:

Year	Number of Freshmen	Number of Graduates
1940	33,200	15,000
1941	36,000	16,000
1945		8,000
1946	91,000	12,000
1947	57,500	21,000
1948	46,700	32,000
1949	36,500	45,000
1950	29,400	52,000
1951		38,000
1952		26,000 (estimated)
1953		20,000 (estimated)
1954		12,000-17,000 (estimated)

The number of graduates which, it is estimated, can be absorbed in the next few years varies widely, since the figures are based on assumptions of our civilian and military life which may or may not be fulfilled. Nevertheless, by any estimate one chooses to use, it is clear that the demand for engineering graduates for at least the next four to eight years will considerably exceed the supply and may do so by a factor of severalfold.

The attrition among engineering students is large, for nearly half who enroll as freshmen drop out of engineering studies before graduation. For this reason, figures on freshman enrollment bear only a rough relation to the number of engineers who will take their degrees four years later. Thus, although the graduating classes in 1949 and 1950 were large, numbering 45,000 and 52,000 respectively, they were considerably smaller than that group who initially embarked on engineering training at the end of World War II.

But even these bumper crops did not completely fill the gap produced during the war years and, to state the matter conservatively, there has been little difficulty in placing engineering graduates in the past decade. Only 38,000 engineering students graduated in 1951 when college placement offices found themselves distressingly unable to meet personnel demands. Ignoring any withdrawals for military service, only some 26,000 engineers are expected to be available in 1952 against need for 34,000 engineering graduates. Thereafter, all current estimates indicate that classes leaving engineering colleges are expected to decline over the next several years until 1954 when some 12,000 to 17,000 will earn their engineering degrees – the actual number depending upon the fraction of preparatory school students who choose the slide rule as a mark of their professional calling during the next year or so.

As the slightly larger classes of children born in the post-depression years reach college age, the number of engineering graduates may be expected to increase slowly after 1954. At least, there will be increased raw material from which to draw. No substantial improvement should be expected, however, until after 1960. It must be remembered that in the past only about one-third of all high-school graduates have shown that combination of ability, interest, and financial means that are necessary to make a college student. From this fraction must be drawn a very large percentage of all professional and brain workers who enter the economy – the lawyers, physicians, architects, editors, economists, teachers, businessmen, administrators, and so on – all of whom depend on a college training as a vital part of their education. Of the nation's adult brain workers, currently believed to number about 1,500,000, practicing engineers constitute about 25 per cent.

According to Solomon C. Hollister, Dean of the Engineering College, Cornell University, only 3 per cent of the prewar high-school graduates desired to enter engineering schools. But this percentage will have to be substantially increased to do much good.

Between 1952 and 1958, high-school graduates will average about 1,200,000 annually. Not all of these graduates (probably less than half) will enter college. Only if the engineering schools could manage to attract 5 per cent of the graduating classes, or 10 per cent of the young men of this group – some 60,000, which now appears to be a most optimistic figure – is there even a likelihood of enough raw material to fill the needs for engineering personnel. Substantially, there are no other sources of potential engineering students. It takes about 17 years to grow a college freshman, and very little can be done to hasten the process. It takes another four years to give him a basic training in engineering. Today, postgraduate work is increasingly necessary in many fields and the educational process is, accordingly, lengthened. At present, the most serious needs in technical man power are for men with advanced degrees.

"University Research Potential"

Somewhat belatedly, government and industry have recognized the seriousness of this problem. A number of agencies – governmental, educational, and professional – are giving this matter their attention in an effort to minimize the deleterious effects of past miscalculations, so far as this may be possible. In this connection, a notable report has recently been issued by the Engineering College Research Council of the American Society for Engineering Education. At the request of the Research and Development Board, Office of the Secretary of Defense, the Council made a survey of the scientific and engineering research resources of American colleges and universities. The survey was conducted under the supervision of A. F. Spilhaus, '33, Dean of the University of Minnesota Institute of Technology. Data for the report, "University Research Potential," were compiled and edited at M.I.T. by John I. Mattill, Secretary of the Engineering College Research Council and Assistant Director of the Institute's News Service, and Jean P. Stevenson, Assistant Secretary of the Research Council. The report gives an impressive picture of the facilities in man power and equipment available in this country for engineering and scientific training. Its primary purpose, however, is to indicate where military research and development might best be expanded in American educational institutions without harm (and possibly with distinct benefit) to the teaching efforts of such institutions.

That such a study was due, becomes apparent when one takes note of the spectacular rise in research and development work in the United States since World War II. While industry has, of course, increased its already large-scale efforts in this direction, the greater portion of the rise is attributable to government-sponsored work. A series of extraordinary accomplishments in military research (perhaps development would be a more precise term) were effected during World War II. Under conditions of a true peace, perhaps the wartime research program may have reverted to a moderately expanded prewar scale. But, under the present circumstances, military and civilian policy makers alike (many of them already conditioned to respect the power of scientific research), became convinced that survival in an increasingly dangerous world depended critically on a continuous, large-scale, technical effort. Thus moderate normal growth gave way to an almost explosive expansion.

Although the total bill for government research was but $67,000,000 in 1940, military research budgets alone, just prior to the Korean conflict, had reached an annual level of more than $500,000,000. The current military research allotment of $1,100,000,000 requires the services of about 56,000 research scientists and engineers and thereby absorbs about 43 per cent of the total personnel of this type available in this country. By 1952, the annual military research expenditures, including those for the Atomic Energy Commission and the National Advisory Committee for Aeronautics will be at the rate of $1,300,000,000 or about $8.50 per capita. In mid-1950, the Atomic Energy Commission alone employed approximately 6,400 engineers and about an equal number of scientists. It is expected that around 65 per cent of the nation's research personnel will be required for military research in 1952. When measured either in amount of money spent or in the numbers of technically qualified persons engaged, government research is truly "big business."

Engineers in College

In contrast to the concentration of technical personnel in governmental agencies, the colleges and universities of the country employ only about one engineer to every 40. All told, their staffs include about 25,000 faculty members and senior research workers in the fields of engineering and science. In addition, these educational institutions are able to call on about 27,000 instructors, junior research workers, and graduate students. With this group, which includes about 20 per cent of the nation's research personnel, the American colleges and universities were conducting about 9¾ per cent of the total military research program in mid-1950, and they are expected to conduct about the same proportion of the vastly larger research totals scheduled for this year. All this military load must be accomplished without injury to the basic research programs or to their primary teaching responsibilities. Truly college professors – at least those in the physical sciences – have long ago left their ivory towers. But are their talents used as effectively and efficiently as possible?

To determine whether the country's unique human resource of university research personnel was being utilized to capacity, the Engineering College Research Council undertook a census of the specialized skills and equipment currently available in our institutions of higher learning. The survey was made by means of an elaborate questionnaire, so designed that the information in the replies could be coded and processed by punch-card equipment. Although such a procedure formalized the presentation of the data and, to some extent, restricted the type of information that could be elicited, it greatly speeded the required analysis and kept accounting errors to a minimum. Questionnaires were sent to 990 colleges and universities throughout the United States and its territories. By the closing date for reporting, over 700 schools had replied of which about 200 indicated they had no resources for the type of research indicated. The report covers statistics for the remaining institutions; 517 in all co-operated in the survey.

A principal fact that emerged from this study is that 11 institutions accounted for 50 per cent of the Federal research and development expenditures in colleges and universities over a three-year period. Funds spent by full-time research staffs, as well as by the faculty, are included in these figures. If we consider only time devoted by faculty members and senior research staff, it is found that 15 schools, controlling 20.5 per cent of the total faculty and senior research staff personnel, contribute half of the time which educational institutions give to defense projects. In these 15 schools, research occupies almost as much of the total school effort as does teaching, about three-quarters of the faculty participate to some extent in research, and currently, the bulk of research time is spent on defense problems.

The remaining half of the time which colleges and universities devote to defense research is accounted for by 510 other institutions reporting research potential. In this numerically much greater group, only 45 per cent of the faculty members are active in research, and military projects absorb 38 per cent of the total research time. Overall, the 15 universities who lead in defense research devote about one-third of their total effort in this field, whereas the remaining educational institutions devote about one-twelfth of their time to defense work. In a group of small, highly endowed, liberal arts colleges, 60 per cent of the faculty members considered qualified to do research were so engaged, but less than 20 per cent of the research time was devoted to problems of national defense.

Teaching versus Research

In the various fields of engineering and science, there are approximately 25,000 members of the faculties and of senior research staffs. Of this group, about 20,000 were considered qualified to do research, and 12,700 were actually engaged in research. The fact that approximately 8,000 capable faculty members are not engaged in research, in one or another field of science or engineering in which they have been trained, does not necessarily imply a waste of talent. There may be good reasons why it is undesirable to use every last qualified research person in our educational institutions for research investigations, for the nation needs research administrators and teachers as well as laboratory workers. But this fact does indicate that there is a significant reserve of research ability which can still be tapped.

Although hardly an unexpected conclusion, one of the points emerging from the statistics of the report on "University Research Potential" is that the ratio of students to staff varies greatly among the 517 institutions whose facilities were reported. For some schools it would seem (at least to a layman in the educational field) that a reduction in the teaching load would be a necessary preliminary to a more active role in the military research program. If student bodies continue to shrink, in accordance with present predictions, the necessary slack may be forthcoming. In any case, the report suggests some participation in research by an increased fraction of the nation's faculties might react to the betterment of engineering teaching. Still it must be remembered that teaching, rather than re-

search, is the primary function of an educational institution, and there is little to be gained by converting a good teacher into a bad research worker. It is only when research and teaching go hand in hand that we may expect extracurricular investigations to benefit tomorrow's crop of engineers and scientists through the more effective teaching which research makes possible.

In many of the country's smaller educational institutions the number of personnel available for research is quite small, of course. Moreover, the number of fields in which these schools can claim expert knowledge in science or engineering is correspondingly limited. So, too, is the stimulation that can be obtained by the cross-fertilization of ideas which comes as a natural consequence when qualified personnel of diverse interests, or in different departments, are able to rub shoulders in a common attack on the same problem.

Problems suitable to the solitary worker and adjusted to his interests and the available equipment are undoubtedly more difficult to find than those which are best tackled by a sizable group of people with properly related skills. It is understandable that much of the military research program has tended to channel through relatively few institutions who are so large and so well equipped that virtually any problem in a broadly defined area is likely to receive adequate attention. Yet, says Dean Spilhaus, "there are a large number of defense research needs, even those lying outside the range of fundamental research in its narrowest definition, which can readily be provided in packages suitable for the small college laboratory." It is here, too, that the largest amount of unused research capacity, within the above limits, appears to exist.

Colleges and Defense Research

A broader deterrent to a more active participation by the colleges in defense research is that the ratio of personnel in the various fields of knowledge has been set over a long period of time when the determining factors in the training and choice of staff were the peacetime needs of the civilian economy and the requirements of basic research in the sciences. The field containing the largest number of faculty members and full-time senior research workers is chemistry, with a total personnel of 3,711 in all the institutions surveyed. Next in order are mathematics with 3,297 members; physics with 2,628; psychology and human resources (a field quite different from that of the physical and engineering sciences with which University Research Potential is largely concerned) with 2,432; mechanical engineering with 2,002; civil and sanitary engineering with 1,698; and so on to the smallest field reported – that of marine engineering with 78 staff members. The six largest fields, enumerated above, account for almost two-thirds of the total number (24,881) of staff members reported, and also account for 60 per cent of those considered qualified to conduct research.

Current requirements in defense research, however, are predominantly in the fields of physics, electronics, chemistry, electrical engineering, and aeronautical engineering. More than 80 per cent of the research time in electronics and aeronautical engineering, and more than 70 per cent of that in electrical, marine, and metallurgical engineering is devoted to projects connected with national defense. About half of the research effort in mathematics, slightly less than half that in mechanical engineering, and about one-third that in civil and sanitary engineering is so devoted. Nearly half the military research program is in the fields of physics, chemistry, and electronics, but the colleges and universities have only about 30 per cent of their staffs in these fields.

M.I.T. Photo

Among the unusual facilities which American colleges have available for the nation's current research program are 4 betatrons, 6 synchrotrons, and 14 linear accelerators. Of the latter units, the Institute's 12-million-electron-volt Van de Graaff generator, shown above, is an outstanding example.

Perhaps the most important single point disclosed by the survey is that, of approximately 8,000 faculty members considered qualified to do so, but not currently engaged in research, the great majority are in the liberal arts colleges and the smaller technical schools. More than 1,000 of these 8,000 are active in mathematics; 940 in mechanical engineering; 880 in chemistry; 775 in civil engineering; and 725 in physics. The utilization of this group of 8,000 for part-time scientific investigation would expand our present senior collegiate research personnel by 47 per cent. This is a significant increase but it is not the only string to the bow.

"Another way in which the tremendous needs for defense research may be aided, not only immediately but more particularly in the future, is by increasing the ratio of graduate students to full-time senior faculty and staff," says Dean Spilhaus. On the average,

(*Continued on page 202*)

The Significance of the Helicopter

II. Transport Helicopters

Commercial Helicopter Service May Soon Be Commonplace

By L. WELCH POGUE

THE first section of this article which appeared in the January issue of The Review, discussed the small helicopter, tracing its historical development and pointing out its operational characteristics. The various types of small helicopters were described, and their use in agriculture, oil and mineral detection, forest service, cartography, and as a private vehicle was given. A basis for cost consideration and an account of the military applications of the small helicopter to date were included. In the concluding section in this issue, the case for the transport helicopter is presented.

Large Helicopter Types

Although few outside the industry are aware of it, because all production is now going into military hands, helicopter aerial trucks and busses are well past the experimental stage and are now in production in medium-sized form, with even larger ones just around the corner. Although some of the larger types are specially designed for a special assignment, it is nevertheless true that all are fundamentally intended for use in the transport of people and cargo. A brief catalogue of these machines, as produced chronologically, would include the McDonnell XHJD-1, the Piasecki HRP-1, the Piasecki HRP-2, and the Piasecki HUP, the Bell-48, and the Sikorsky-55. Their cruising speeds vary as between the different models from 86 to 120 miles per hour.

The McDonnell XHJD-1* is an experimental twin-engine, twin-rotor helicopter. It is a 14-place machine with a useful load of 5,189 pounds. Built under a Navy contract and first flown in 1946, it is not in production.[61-63]

The Piasecki HRP-1, HRP-2, and the H-21 are a series of machines developed for the military services on the same basic design. They are single-engine, twin-rotor machines and, depending on the seating plan, can accommodate from 11 to 21 passengers. The commercial version of the H-21, the PD-22, has a pay load of 3,500 pounds. The H-21 is a higher-powered version of the HRP-2. The HUP is a slightly smaller seven-place machine with a similar configuration designed for intrafleet operations in the Navy. The HRP-1 was first flown in 1945 and first delivered to the Navy in quantity in 1947. Today many of them are in service for the Navy, Marine Corps, and Coast Guard. The H-21 is in quantity production for the Air Force as an arctic rescue ship, and the HUP is in production for the Navy as a shipboard craft. [42, 61-65]

*Please see numbered references at end of article, page 212.

Sikorsky helicopter, bearing the Air Force designation H-19, was first flown late in 1949. It is the prototype for a later model, S-55, now in quantity production, which carries a useful load of 2,533 pounds and seats 12 persons.

The Bell-48 (known to the Air Force as the H-12) is a 12-place machine which has been flying in its production version since November, 1949. It is a single-motor machine incorporating the same rotor design principles as Bell's smaller helicopter of the 47D series. It has a useful load of 2,471 pounds. It is now in production for the Air Force.[61-63, 66]

The Sikorsky-55, lineal descendant of the S-51, is a 12-place, single-engine, single-rotor machine first flown in the fall of 1949 as the Air Force H-19. It has a useful load of 2,533 pounds. It is now in quantity production.[61-63, 67]

In addition to the foregoing machines, all of which have flown and all of which, except the XHJD-1 are now in quantity production, a number of other machines even more interesting from the point of view of mass transportation are in the mock-up and testing stages. Among these are the Piasecki XH-16, the Hughes XH-17, and the Bell XHSL-1.

The XH-16 is a twin-engine 40-passenger machine, comparable to the DC-4 in the fixed-wing field, which is being developed by Piasecki for the Navy and Air Force and is now in the prototype stage. An alternate configuration would provide a detachable pod or capsule, similar to that on the Fairchild C-120, utilizing the tractor-trailer principle of the highway truckers.[64]

The Hughes XH-17, which has been undergoing tie-down tests, is a huge "flying crane" helicopter utilizing jet engines on a single rotor with an estimated useful load of 20,000 pounds or 10 tons.[61-63, 68]

The XHSL-1 is a Bell design which won a recent Navy contest for a helicopter designed primarily to meet the requirements of antisubmarine warfare. Emphasizing long-range and heavy load-carrying capacity, it has a single motor, twin rotors, a configuration with a rotor fore and aft, and is now in the mock-up stage. The details of its performance are not available.[61, 68-71]

On March 14, 1951, contracts were awarded by the Navy Bureau of Aeronautics for two large machines to meet the requirements of the Marines for an assault transport helicopter. Although all details of these machines have not been released, it is known that the Sikorsky winning design included a single five-bladed rotor with a conventional piston engine, while the McDonnell winner will have a single three-bladed jet-propelled main rotor.

Despite the inherent safety of helicopters provided by their autorotational characteristic in the event of engine failure, considerable attention has been given to the development of twin-engine machines which could maintain altitude on a single engine. Such machines would permit lower and more direct flight over crowded metropolitan areas because of the elimination of the necessity that single-engine equipment always be within gliding distance of a suitable landing spot. As noted above, the McDonnell XHJD-1 and the Piasecki XH-16 are both twin-engine machines, and all the leading manufacturers have testified that their machines were readily adaptable to twin engines and most of them are working on the project.[72, 73] It has been stated that the application of gas-turbine engines to helicopters will greatly increase pay load for the same size helicopter.[64]

McDonnell helicopter XHJD-1, built for the Navy, is a 14-place machine with a useful load of 5,189 pounds. It is a twin-rotor, twin-engine helicopter.

Military Uses of Transport Helicopters

To what uses do the armed services plan to put these machines? The answer is a combination of many of the past uses of the truck, the liaison airplane, the ambulance, the glider, the parachute, the destroyer, and other surface means of transportation. Such is the versatility of the transport helicopter that it can and does perform many of the functions of each. Major General Frank A. Heileman, chief of the Army Transportation Corps, has, in fact, been quoted as saying that at last, in the helicopter the Army has found a mechanized replacement for the mule.[74]

The military interest in transport-size helicopters is succinctly summed up in the following statement prepared in the fall of 1950 by the Helicopter Council of the Aircraft Industries Association:

The necessary restrictions of military security do not permit us to give details of the procurement programs of the Armed Forces. However, it can be said that helicopters are being procured in far greater quantities than ever before, and that helicopter procurement and operations constitute a much greater proportion of military expenditures and effort than they have heretofore. In fact, over five hundred helicopters already have been ordered under current production programs.

Moreover, transport-size helicopters constitute the major portion of this expanded helicopter production, both in absolute numbers and to a greater extent in expenditure of funds.

The Army officially announced on October 20, 1950 that it is forming a number of helicopter transport companies, each company to be equipped with 23 transport helicopters. The Army announcement further stated that one such helicopter company would be provided for each of the Army's divisions; this, of course, represents a sizeable number of transport helicopters. Moreover, these Army helicopter companies will be a part of the Army Transportation Corps; this fact is of the utmost significance, in that it characterizes the helicopter as a basic vehicle of transportation, placing it alongside the Army's motor transport and its railroad service.

All current Air Force procurement of helicopters is for machines of 10-place or larger size. These larger machines are being used for rescue of numbers of persons over long

The Piasecki HRP-2 tandem helicopter, bearing Marine Corps designation XM-1, is of the same basic design as the HRP-1 and H-21. All are single-engine, twin-rotor machines. Depending upon seating arrangement, from 11 to 21 passengers can be accommodated.

ranges, for the transportation of personnel and equipment, and for tactical purposes.

The bulk of the Navy's helicopter orders are for machines substantially larger than those used in today's certificated helicopter mail services. These are being produced for antisubmarine missions and for transport utility in fleet and ship-to-shore operations.

The Marine Corps is continuing and greatly expanding its use of helicopters as assault transports for troops and equipment. All of the helicopters which it is getting for this purpose are 10-place and larger.

While each of the Armed Forces undoubtedly will continue to have great use for the smaller helicopters for liaison, observation, communications, etc., it is manifestly clear that the greatest military requirements are for helicopters of transport size. The preponderance of production is that of 10-20 place machines, and the emphasis in development is upon helicopters of even larger size.[75]

In addition to the military uses of the small helicopter described in a previous portion of this article, the new large machines open a wide variety of possibilities. In the field where the helicopter really came to fame in Korea – rescue and transportation of the seriously wounded directly from front-line positions to rear-area hospitals – the larger machines are obviously better adapted. In Korea the seriously wounded were carried in covered litters attached to the *outside* of the helicopters. In the big, new machines, many more injured can be carried in comparative comfort inside the machine where medical attention can be given en route. The advantages are apparent.

Prior to Korea the helicopter was perhaps best known to most of the military for its function of rescuing aviators downed at sea, in the Arctic, or in other inaccessible, but not too distant, places. The longer range and greater capacity of the newer machines make it possible to enlarge this function and to rescue in one flight the entire crew of a downed large bomber hundreds of miles from help. The Coast Guard is so using many of its large machines and the Air Force is purchasing the H-21 in quantity for the specific purpose of such rescues.[61-65]

The movement of men and supplies to points otherwise difficult or impossible of access is a prime job for the transport helicopter. Whether this movement be from ship to shore where there are no port facilities, or where the port facilities are overcrowded or destroyed, or from a base area to inaccessible outposts on mountain tops, or across bridgeless rivers or canyons, the transport helicopter carrying 10, 20, or 40 men, or the equivalent weight in supplies, is the answer to a prayer.

The following dispatch printed in a Washington, D.C., newspaper is an example of the work of a helicopter in mountain battle:

> Eastern Front, Korea, Sept. 20 (AP)–Giant helicopters lifted a company of battle-ready Marines onto a rugged mountain on the eastern front today. It was the first time helicopters have moved troops into combat. The job was done without loss of a single man or plane. It would have taken two days to climb the mountain and occupy it. But in four hours the giant (helicopters) landed a reinforced marine company and supplied it with food and ammunition. A helicopter even strung telephone lines linking the almost inaccessible hill with Marine headquarters in the rear. . . . The first six helicopters hovered about eight feet above the mountain while Marines climbed down knotted ropes. The first troops down cleared 25-foot square landing areas. The remaining 15 helicopters landed to debark their men and gear. . . . The 'copters took an average of 20 seconds to land, unload and take off again. Each helicopter made several trips. The big machines used today can carry as many as 10 men each. Maj. W. P. Mitchell . . . executive officer of the Marine helicopter squadron HMR-161, said the maneuver was relatively fast. "I think this is just the beginning of this type of warfare," he said. "It will completely change military science. We've been shooting for this for three and a half years. I'm happy to be in the outfit that is the first to do it."[76]

A 10-ton helicopter can move vast amounts of supplies, ammunition, and equipment directly to the using units. This is exciting. Never has the service of supply known anything like this, but we may be sure it will use new facilities fully.

Apply the same concept to the rapid movement of completely equipped combat troops, and the transport helicopter becomes a formidable weapon. The Marine Corps was one of the first of the military services to appreciate the tactical significance of the helicopter.[42] Consider the implications of this on the technique of the amphibious assault. Of primary importance is the element of surprise. A fleet of assault transport helicopters, alighting from offshore carriers just before dawn and proceeding at a speed of well over 100 miles an hour, can allow troops to consolidate positions long before the enemy has had an opportunity to muster a concerted defense. Alternate landing points may be selected, unaffected by the necessity of suitable beaches required by amphibious craft, leaving the final determination of a landing place until the last moment which is calculated to take the greatest advantage of the surprise element. Indeed, the sandy beach and extensive artillery preparation as used in World War II become unnecessary, because the invading troops can be landed in quantity well inland, behind the coastal defenses. With adequate fighter air support, the same technique which jumps the coast line can also jump an enemy front line and land a large element well behind the enemy lines to by-pass him or harass him from the rear. A revolution in tactics is about to occur. The Marines have been working out new techniques with a transport helicopter unit since 1948.[64] The official Marine Corps publication contains the following statement on this subject:

> . . . The Marines of HMX-1 — Marine Experimental Helicopter Squadron at the Quantico Marine Corps Air Station — have been working out another tactical wrinkle for the "egg beaters."
>
> The little "flying windmills" have been used at Quantico since 1948, and their training has centered around making beach assaults with a minimum of the slaughter usually attributed to old methods of amphibious attack . . .
>
> It's quite likely that when Marines land from now on, it'll be from the air as well as the sea. . . .[77]

The Navy believes so firmly that the helicopter is the answer in combating the submarine that, as noted above, it has had a large helicopter designed for this particular purpose.[69] The large transport machine with its great range, its capacity for carrying large amounts of search equipment and antisubmarine weapons, and its ability to search slowly and hover near a possible target appears destined to improve greatly submarine-hunting technique at a fraction of the cost, and with a tinier fraction of the man power required by former methods.

Finally, in civil defense activities the transport helicopter looks like a natural. At the Eniwetok atomic bomb tests in 1948, helicopters were found to be a safe means of approaching the contaminated area in the immediate post-blast period and they were extensively and successfully used for this purpose.[78] A modern metropolitan area devastated by the atomic bomb would have, for some time, absolutely no other means of transporting medical and rescue personnel into the affected area, evacuating the injured, and maintaining effective liaison with the outside. In an area such as Manhattan Island, which could be completely isolated from all other means of transportation by an atomic blast, the need for such equipment is a crying one. In fact, the commander of the Eastern Air Defense Force has said that for use in such an emergency, the helicopter "would be invaluable."[79]

Commercial Uses of the Transport Helicopter

In the light of all these considerations, and the fact that the ability of the helicopter to perform all of these functions has been tested and proved, it is clear why the military services have loaded down the principal manufacturers with large orders for transport-size machines.[80] All of the major helicopter manufacturers have embarked upon extensive plant expansion programs.[5]

The mere existence of such new, large transport helicopters has already had an impact on commercial

Bell helicopter, bearing the Air Force designation H-12, has been flying since November, 1949. This single-rotor machine has a useful load of 2,471 pounds.

aviation thinking and planning. When they start coming off mass-production assembly lines – a prospect which is clearly foreseeable right now–another revolution in tranportation will begin.

The Civil Aeronautics Board has before it petitions from several applicants who propose to utilize these machines to carry passengers in various metropolitan areas, including New York.[81] In renewing the certificate of public convenience and necessity of Los Angeles Airways, Inc., for five years, recently, the Civil Aeronautics Board authorized the carriage of passengers, in addition to mail and property, on certain of its routes.[82] It appears, therefore, that this company will pioneer in the actual scheduled carriage of passengers in certificated operations. The company not only plans to inaugurate passenger service from the airport to the suburban communities with Sikorsky-55's, but already has plans prepared for a passenger heliport on top of a large office building in downtown Los Angeles.[83] It seems clear that the large helicopter is ready for safe, regular, efficient, and economical carriage of passengers.

As planned by Los Angeles Airways, the first large-scale passenger operation will probably be from airport-to-suburban communities, thus complementing the air lines and helping to solve one of their terminal time-delay problems. Speedways have generally been built to serve the suburban-to-downtown trips, not suburban-to-airport journeys. Hence, one of the helicopter's great contributions will be in spinning out its own speedway to the airport in the lower levels of air, above the congested traffic below, and beneath the flight paths of the fixed-wing transports.

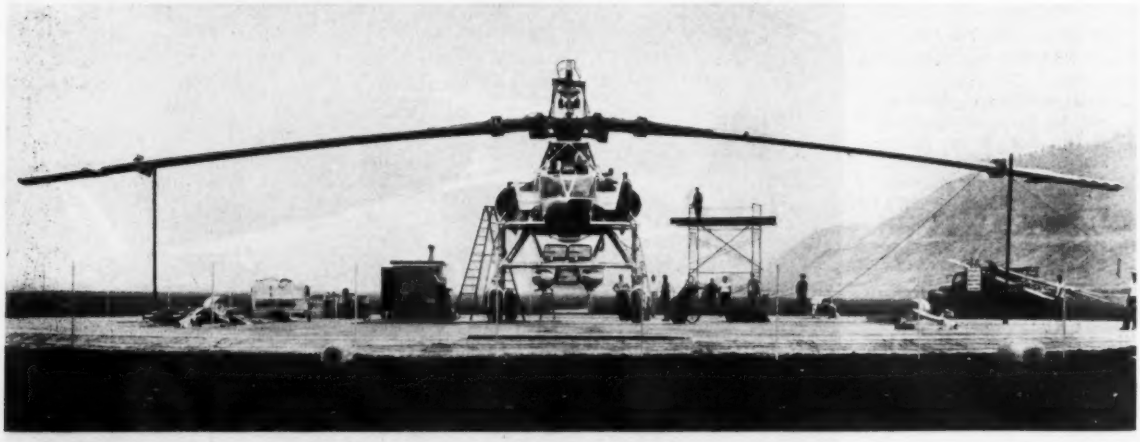
Next, when adequate heliports in downtown areas are available, the operation from airport to downtown, and reverse, will offer a large business. But that cannot come until there are enough heliports available at travel transfer points to make possible competition with the limousines and taxis.

Finally, it does not require a very keen ear to detect, in these early rumblings, the roar of a large and steady procession of helicopter commuters settling down in the centers of our big metropolitan areas each morning. What the automobile and the commuter train began, in making it possible to work in the city and to live in the country, the transport helicopter will shortly extend and magnify. The time required to commute from the suburban village green to the downtown office building will be sharply reduced and, by the same token, the area within which commuting becomes possible will be greatly extended. An hour's commuting time is not considered excessive by the hardened veteran, and yet an hour in a nonstop commuter helicopter – in machines now in production – would bring him into the center of the city from 100 miles away. In the *New York Case,* the Port of New York Authority recognized its responsibility and undertook to assist in the provision of suitable heliports, including the construction of one on the roof of its new bus station on Eighth Avenue in New York, when the demand exists.[84]

The smoothness of the ride and the reliability of service in all weather, both of which will be essential before this picture can completely materialize, have both been signally forwarded by two developments of the past year. Los Angeles Airways has been authorized by the Civil Aeronautics Authority to operate its mail-carrying helicopters on instruments when the weather is too bad for contact flying, and the successful control of helicopter flight by automatic pilot was worked out by Sperry Gyroscope Company and the Navy Department.[85-89] These two developments, which to a certain extent complement each other, are significant advances toward large-scale scheduled helicopter operations.

The effect of the metropolitan helicopter service in assisting the air lines to penetrate the relatively short-haul market, by minimizing the terminal time delays at either end of the trip, has already been mentioned. In Detroit, when access to the air lines was made more difficult by moving the terminal from the Municipal Airport in the heart of the city to Willow Run, 32 miles away, air traffic to Cleveland dropped from 17,000 per month to around 7,000, and to Grand Rapids from over 1,400 per month to around 400.[90] Conversely, when the time required for a passenger to travel between mid-city and the airport is reduced through short helicopter rides, it is expected that short-haul air traffic will be greatly increased. But this, after all,

(*Continued on page 206*)



The Hughes XH-17 helicopter uses jet engines to power its single rotor. This experimental unit has an estimated load of 10 tons.

THE INSTITUTE GAZETTE

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Life Members Emeriti

LAST month the election of six men to life membership in the Corporation was reported in The Review. These men will fill six of the vacancies resulting from the transfer of seven life members to the newly created status of life member, emeritus.

In creating an emeritus status for life members, the Corporation has taken a step of considerable significance. Under the new procedure, adopted by the Corporation at its meeting on December 3, emeritus membership became available immediately to life members past the age of 70. However, transfer to this status is entirely optional for all those whose election to life membership preceded the adoption of the new policy, and each request for transfer of the status is subject to approval by the Executive Committee. For all life members elected after this date, transfer to emeritus status will be optional at age 70, but compulsory at age 75, except that the Executive Committee shall have the right to ask extension of active service on a year-by-year basis when some unusual situation makes this desirable.

Life members emeriti will be considered as continuing members, receiving all notices and reports, and will be welcome at all Corporation meetings. They will be free to participate in all discussions but without vote, and will be relieved of all committee assignments, except that, on their request, they will be invited to attend such Visiting Committee meetings as are of special interest to them.

The new policy on membership is an outgrowth of suggestions from several of the older Corporation members that the problem of age distribution in the Corporation be discussed and analyzed. Later discussion revolved around the question of whether the effectiveness of the Corporation could be improved by some device which would permit a greater flow of new blood into the Corporation membership, especially from the group of former term members who have been particularly interested and helpful. In order to meet the technical requirements of the Corporation charter and still add younger men, who would be able to take on the obligations of regular attendance and committee service, it was necessary to create a new type of membership for older men which would not entail the obligations of committee membership nor the right to vote, but which would allow these men to continue to give the Corporation the benefit of their advice and counsel.

The seven life members who have elected to assume emeritus status are: W. Cameron Forbes of Boston; Pierre S. du Pont, '90, of Wilmington, Del.; Franklin W. Hobbs, '89, of Boston; Gerard Swope, '95, of New York, N.Y.; Victor M. Cutter of Boston; Lammot du Pont, '01, of Wilmington, Del.; and William C. Potter, '97, of New York, N.Y.

Mr. Forbes graduated from Harvard in 1892 and was elected to life membership in the Institute's Corporation in 1913. In succeeding years, he has served as chairman of Visiting Committees for the Department of English and History, the Medical Department, and the Division of Industrial Coöperation; and, in addition, has served as a member of Visiting Committees in Electrical Engineering, Modern Languages, Architecture, Mechanical Engineering, Aeronautical Engineering, and Meteorology.

Mr. Cutter was elected to life membership in the Corporation in 1929. He served as chairman of the Committee on Museum from 1941–1948 and has also served as a member of the Committee on Finance and Auditing. He was chairman of the Visiting Committee on the Department of Economics and Social Science from 1938–1941 and chairman of the Visiting Committee on the Department of Mathematics for the year 1950–1951. Other Visiting Committees on which he has served are: Business and Engineering Administration, Biology and Public Health, Division of Industrial Coöperation, Modern Languages, and Naval Architecture and Marine Engineering.

Lammot du Pont served as a term member of the Corporation from 1928–1933 and was elected to life membership in 1934. Since that time, he has served as a member of the Committee on Membership and of departmental Visiting Committees in Chemistry, Chemical Engineering, Civil Engineering, Hygiene, Biology, and the Division of Industrial Coöperation.

Mr. Potter was elected to life membership in the Corporation in 1936 and later served as a member of the Committee on Finance and the Committee on Membership. He was chairman of the Visiting Committee on the Department of Business and Engineering Administration from 1948–1950 and chairman of the Visiting Committee on the Department of Metallurgy in the year 1950–1951. He has also served on Visiting Committees for Biology and Geology.

Pierre S. du Pont was elected to life membership in the Corporation in 1916 and since then has served on departmental Visiting Committees in Physics and English.

Mr. Hobbs was elected to life membership in the Corporation in 1923 and later served as a member of the Auditing Committee and the Committee on Museum. He was chairman of the departmental Visiting Committee for Textiles in 1937–1938 and served also as a member of Visiting Committees in Economics and Social Science, Chemistry, and Mechanical Engineering.

Mr. Swope was elected to life membership in the Corporation in 1923 and served as a member of the Executive Committee from 1930–1946. He was also a member of the Committee on Library and of the Committee on Membership, serving as chairman of the latter from 1937–1948.

M.I.T. Photos

Carl F. Floe, '35
Assistant Provost

Julius A. Stratton, '23
Vice-president and Provost

Joseph J. Snyder, 2-44
Vice-president and Treasurer

New Administrative Officers

IN keeping with the Institute's postwar growth and widened responsibilities, three new administrative appointments have been announced by President Killian. Julius A. Stratton, '23, and Joseph J. Snyder, 2-44, have been appointed vice-presidents, and Carl F. Floe, '35, has been appointed assistant provost.

As vice-president and provost, Dr. Stratton will be primarily concerned with the Institute's educational and research program and will assist Dr. Killian in discharging the responsibilities of the President's Office. He will share with the deans the administration of educational policy as formulated by the Faculty and will devote himself primarily to the Institute's educational program. Dr. Stratton joins Mr. Snyder as a member of the Corporation of M.I.T.

As vice-president and treasurer, Mr. Snyder will have executive responsibility for the fiscal and business management of the Institute.

In assuming the post of assistant provost, Dr. Floe will be primarily concerned with problems relating to Institute programs of sponsored research and will work closely with the director of the Division of Industrial Cooperation. In addition, the assistant provost will serve as chairman of the Patent and Patent Management Committees and will aid in executing the duties of the Provost's Office.

After having served M.I.T. with distinction since 1924, in a variety of teaching and administrative positions, and after an outstanding war record which won him the Medal for Merit, Dr. Stratton was appointed provost in April, 1949. His biography appears on page 516 of the June, 1949, issue of The Review which takes notice that Dr. Stratton is the first academic officer to serve the Institute in the post of provost. Since mid-1949 he has been concerned with the administration of educational activities which do not fall within the jurisdiction of any single school, and with the coordination, in concert with the deans, of interschool educational and research activities.

Mr. Snyder has been treasurer of the Institute since July 1, 1950, as recorded on page 378 of the May, 1950, issue of The Review. He is widely known for his active participation in the financial and business interests of the Institute, as well as in investment management, financial administration, and industrial management affairs in Boston.

Mr. Snyder is a partner in the Colonial Management Associates of Boston, investment advisers to the Finance Committee of the Massachusetts General Hospital and other organizations. He is also vice-president of the investment trusts, the Railway and Light Securities Company and the Gas Industries Fund. He is a trustee and member of the Board of Investment of the Boston Five Cent Savings Bank, a director of the Michigan Seamless Tube Company, and a director of the Transcontinental Gas Pipe Line Corporation.

Born at Dawson, in the Klondike Region of the Yukon Territory, Canada, Dr. Floe received the degrees of bachelor of science and master of science at Washington State College in 1930 and 1932, respectively. M.I.T. awarded him the degree of doctor of science in Metallurgy in 1935.

From 1930-34 Dr. Floe was an instructor in metallurgy at Washington State College, and an assistant professor from 1935–36. He held the same post at the University of Notre Dame from 1936–39, and at the Institute from 1939–42. In 1942 he was appointed associate professor and in 1950 full professor of Metallurgy at M.I.T. He was named executive officer of the Department of Metallurgy in 1943.

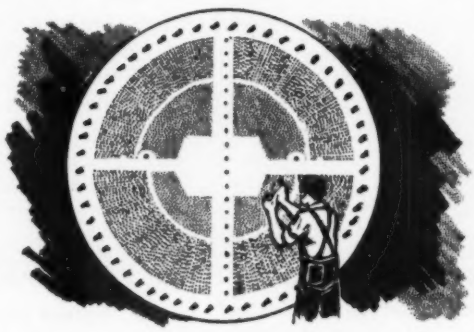
During World War II, Dr. Floe served as a consultant for the United States Army Quartermaster Corps and for several companies including the Gorham Manufacturing Company, Pratt and Whitney Aircraft Corporation, Nitralloy Corporation and Vermont Marble Company. At present, he is a director of the White Pigment Corporation, Boston Electro Steel Casting, Inc., and Nitralloy Corporation.

(Continued on page 198)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

American business lays great emphasis upon salesmanship, and correctly so, because orders keep a company busy, provide employment, meet the payroll, pay for materials, amortize machines and buy new ones, and, if management is skilled, provide profits. Yet there are times when it is best to turn down an order. If, for example, a would-be buyer really doesn't need what he asks for, it is good business to tell him so, and show him a better way to satisfy his need. Revere has done this many times. In a recent instance, we were able to save a prospective customer some $30,000. This was done while working with a public utility, an important user of condenser tubes. Examination of leaking tubes from one of its condensers showed that the trouble was due to a combination of erosion and corrosion at the inlet ends; the tubes were in good condition otherwise.



The condenser contains some 4,100 tubes, and to replace them would cost about $35,000, surely a high price to pay for damage to a few inches at one end of each tube. Revere, instead of taking the order for 4,100 tubes, recommended use of a device to cure the trouble. There are several different makes of such devices, intended to be inserted in the leaky ends, thus effecting a repair. When conditions are suitable, several more years of service may be obtained from the original tubes. In the case under consideration, the cost of the repair was only $5,000.

So successful has this recommendation proved for the utility that it has been followed for a second condenser. This has about 2,700 tubes, and a corresponding saving has been realized. Of course, one might say that if the condensers had been properly designed in the first place, erosion-corrosion at the inlet ends would not have occurred. This is true, but the fact is that many utilities and other companies operating steam condensers have found it necessary to put burdens on them in excess of those for which they were originally designed. This necessitates increasing the velocity of cooling water, which in turn makes erosion more likely. Also, water conditions often change over a period of years, so that more corrosive conditions may build up, particularly in the industrial areas where so many condensers are located.

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THE INSTITUTE GAZETTE

(*Continued from page 196*)

Frank Heads Physics Department

THE appointment of Nathaniel H. Frank, '23, as head of the Department of Physics at the Institute was announced by Professor George R. Harrison, Dean of Science at M.I.T. Professor Frank was appointed acting head of the Department of Physics last spring, as recorded on page 491 of the July, 1951, issue of The Review.

Professor Frank succeeds Professor John C. Slater, who had been head of his Department for more than 20 years. Dr. Slater was recently appointed to the newly created and distinguished post of Institute Professor at M.I.T. and is now on a year's leave of absence to carry on research at Brookhaven National Laboratory on Long Island.

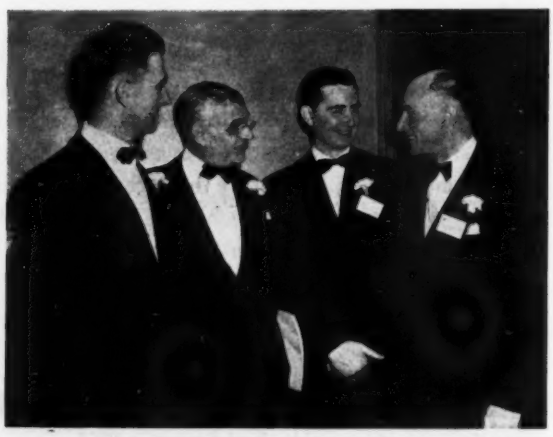
Born in Boston, Dr. Frank received the degree of bachelor of science from M.I.T. in 1923, and the degree of doctor of science in 1927, and has been associated with the Institute ever since. He served the Department of Physics as executive officer from 1949 to July, 1951, under Dr. Slater.

Dr. Frank spent 1929-1930 in Munich, Germany, doing research in theoretical physics with A. Sommerfeld, and in 1935 was a guest of the Institute for Advanced Study at Princeton. During World War II, Dr. Frank contributed important service to research and to development in the war effort.

His war activities may be divided into two distinct phases: first, a period from May, 1941, to January, 1943, during which he was a staff member of the Radiation Laboratory at M.I.T. His work at the laboratory comprised theoretical researches of phenomena associated with the propagation of microwaves.

The second period was after January, 1943, during which he held the post of Expert Consultant, Office of the Secretary of War, with headquarters in Washington. In this post he was engaged primarily in the formulation and monitoring of technical programs designed to meet wartime requirements, especially in the field of radar.

Dr. Frank is well known in the fields of theoretical physics and metallic conduction. He is the author of two introductory texts in physics and co-author, with Professor Slater, of a standard introduction to theoretical physics. A Fellow of the American Academy of Arts and Sciences, he is also a Fellow of the American Physical Society and member of the Association of Physics Teachers.



A.S.M.E. Secretary, C. E. Davies (with glasses), presents (left to right) to Warren M. Rohsenow, Assistant Professor of Mechanical Engineering, the Gold Medal of Pi Tau Sigma; to John D. Stanitz, '42, doctoral candidate at M.I.T., the A.S.M.E. Junior Award; and to Jacob P. Den Hartog, Professor of Mechanical Engineering, the Worcester Reed Warner Medal.

Fassett Appointed Associate Dean

THE appointment of Frederick G. Fassett, Jr., as Associate Dean of Students at the Institute has been announced by President Killian. Mr. Fassett will continue his work as director of publications and director of the Technology Press, but will be freed from his duties as director of the Institute's Summer Session.

As associate dean of students, Mr. Fassett will work closely with Dean E. Francis Bowditch in all phases of life at the Institute for which the Office of the Dean of Students is responsible. He will be particularly concerned, at least in the initial stages of his work, with the dormitory system, the relationship of the Dean's Office to the fraternities, the problems of commuting students, and co-operation of the administration with undergraduate publications.

In announcing the appointment, Dr. Killian said:

> Mr. Fassett has had a long and varied experience both within and without the Institute which makes him admirably fitted to fill this new post and carry out the Institute's policies of developing the whole man, of strengthening and expanding the concept of student life and activities run by and for the students in accordance with the highest standards and traditions of M.I.T.

Mr. Fassett joined the M.I.T. staff in 1930 as an instructor in the Department of English and History, was named assistant professor of English in 1934, and associate professor in 1938. Chairman of the Advisory Council on Undergraduate Publications, Mr. Fassett was appointed, in 1938, editor of The Technology Review, of which he had been an editorial associate since 1935.

In 1945, Mr. Fassett left M.I.T. to become director of publications and public relations for the Carnegie Institution of Washington, a post which he held until returning to the Institute in 1951.

James R. Jack: 1866-1952

PROFESSOR EMERITUS JAMES R. JACK, Head of the Department of Naval Architecture and Marine Engineering at M.I.T. from 1919 to 1936, and a distinguished designer, shipbuilder, and educator, died at his home in Watertown, Mass., on January 6.

Professor Jack aided in the design of the first turbine ship, launched in Scotland by William Denny and Brothers, Ltd., in 1901. He was responsible for the design of about 350 vessels between 1901 and 1918, including the first ship propelled by a combination of steam reciprocating and turbine machinery,

(*Continued on page 200*)

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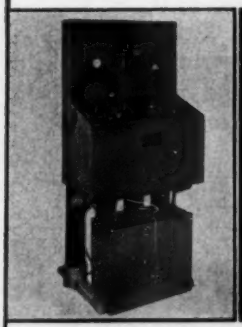

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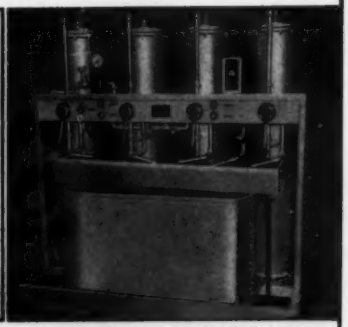

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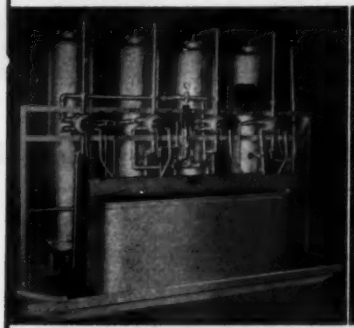
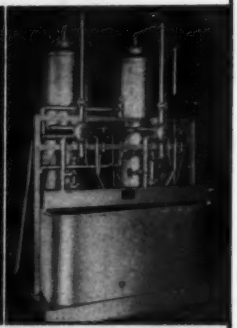


Four-bed Barnstead Demineralizer providing pure, high resistance water for electronic mfgr. 1000 gal/h.



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(*Continued from page 198*)

and later directed construction for Sir Thomas Lipton's contenders for America's Cups, *Shamrock II* and *III*. Professor Jack was awarded the Order of the British Empire which King George V presented to him at Buckingham Palace in 1918.

In 1919 Professor Jack delivered a series of lectures at M.I.T. and the following year was appointed head of the Institute's Department of Naval Architecture and Marine Engineering. He was largely responsible for the establishment of the Institute's Nautical Museum of which he became director in 1924 and honorary curator upon his retirement in 1936 until 1945.

Educational Council Formed

ARTHUR L. BRYANT, '44, Assistant Director of Admissions at the Institute, has been appointed executive secretary of the M.I.T. Educational Council, and will be responsible for assisting M.I.T. alumni groups throughout the country in organizing an educational council on a nationwide basis.

The M.I.T. Educational Council, which will be built around the existing nuclei of Alumni Clubs and Honorary Secretaries, will consist of selected Alumni appointed by President Killian. Council members will be prepared to be of service to school principals and guidance counselors, as well as to students, by providing information and advice relative to the fields in which M.I.T. offers training.

Mr. Bryant, a native of Binghamton, N. Y., graduated from M.I.T. in October, 1944, and subsequently served two years in the United States Navy as an Ensign. He received a second S.B. degree in Business and Engineering Administration from M.I.T. in 1947 and the degree of master of education from Boston University in 1949.

Space for Physicists

THE Visiting Committee on the Department of Physics* met in the office of Professor John C. Slater, Head of the Department, on March 5, 1951. Present at this meeting were: Dr. Slater, representing the Department; Professor Julius A. Stratton, '23, Provost, and Professor George R. Harrison, Dean of Science; and Messrs. Barker, Chesterman, Desmond, Johnson, and Morse, of the Committee.

The meeting reviewed in considerable detail with Dr. Slater the work and progress of the Department as well as its problems. All were gratified at the competence with which departmental affairs are being handled.

The only matter which the Committee believed should be brought to the attention of the Corporation concerned the physical conditions under which the work of the Department has to be handled due to the lack of adequate space provision. The Committee

(*Concluded on page 202*)

*Members of this Committee for 1950-1951 were: James M. Barker, '07, chairman, Francis J. Chesterman, '05, Thomas C. Desmond, '09, Richard S. Morse, '33, Ralph P. Johnson, '36, I. I. Rabi, and Alan T. Waterman.

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Harold E. Koch, '22, President
Elton E. Staples, '26, Vice President

THE INSTITUTE GAZETTE

(*Concluded from page 200*)

realized that the Institute's Administration was aware of the problem, but nevertheless felt that it must emphasize its agreement with Dr. Slater that a new building is necessary to permit the efficient continuance of the Department's vitally important work. At the present time, too, many of the departmental activities are being conducted in dispersed and temporary quarters.

The Committee did not wish to make insistent recommendation to the Institute's Administration for the immediate construction of a building for the Physics Department; it did, however, wish to make as its unanimous and major recommendation that adequate and satisfactory quarters be provided for this extremely important Department at the very earliest feasible time. To that end, the Committee recommended that detail planning for such quarters start immediately.

SHORTAGE OF ENGINEERS

(*Continued from page 189*)

he notes, "each senior member directs the work of two assistants," but there is no basic reason why that ratio should not be raised substantially. Of course, before any such increase in the ratio of investigators-to-directors can be made to yield any net gain, the qualifications of all members of the team will have to be considered carefully and fitted together into a unified working whole.

Although not the primary purpose of the report, the listings in "University Research Potential" give an impressive picture of the material, as well as the human resources, which are currently available in our colleges and universities, not alone for research but for the equally basic purpose of teaching. The questionnaire asked the colleges to list "unusual" items of equipment not commonly found in educational institutions of higher learning. While the interpretation of the word "unusual" varied, the replies listed 12 institutions with digital computers, 28 with analog computers, and 19 with differential analyzers. Cyclotrons were mentioned in 20 replies, 4 institutions had betatrons, 6 had synchrotons, and there were 14 linear accelerators of one type or another,* along with a wealth of other apparatus. Some 52 electron microscopes were listed, and hardly a major technical institution failed to list at least one wind tunnel – a gadget with many variations, for subsonic, transonic, supersonic, hypersonic, low turbulence, high temperature, and climatology tunnels were enumerated.

All of this superb equipment is to the good, and it can and will play an important role in the nation's future technological development. But no amount of physical assets will be of practical value without competent and ample man power to use these facilities effectively. So again we are confronted with the prob-

(*Continued on page 204*)

* The Atomic Energy Commission states that there are now more than 70 particle accelerators of all forms – cyclotrons, cosmotrons, synchrotrons, Van de Graaff generators, and so on – in operation in this country.

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SHORTAGE OF ENGINEERS

(Continued from page 202)

lem of scarcity of technically trained personnel, and may well ask ourselves what can be done to overcome our past shortsighted policies on man-power utilization and how can we best make use of the present and future human resources.

Basically, the solutions to the man-power shortage appear to break down into three categories, dealing with: (1) those already trained or experienced in engineering; (2) those now in, or soon to enter, our engineering schools and from whom tomorrow's crop of engineers will come; and (3) those who, although not material of which engineers are made, can be trained in technical duties of such nature as to free more capable personnel for engineering assignments.

A clear-cut analysis of what must be done about the shortage of technical man power has been supplied by Charles E. Wilson, Defense Mobilization Director. Speaking at the twentieth anniversary meeting of the American Institute of Physics in Chicago in October, Mr. Wilson said:

"First, government, industry, and educational institutions must make the most effective possible utilization of those persons who have received scientific and technical training. Any failure to utilize such personnel in the most effective possible manner plays into the hands of those who want to see our defense mobilization program fail. All departments and agencies of the Federal Government must set the example in this respect.

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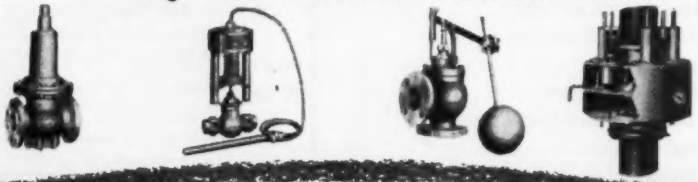

"Second, our educational institutions can develop counseling programs which will result in a larger number of men and women being trained in these fields.† Students with aptitudes for such training can and should be shown that by obtaining scientific and technical training they can prepare themselves for satisfactory employment and, at the same time, make a major contribution to the preservation of our way of life. If this demonstration is made, they will respond. More women, for example, should be enrolled in scientific courses and in engineering schools than is the case today. Their services are needed and will be utilized.

"Third, industry and government should develop both on the job training programs and co-operative training programs with institutions of higher learning and other educational institutions which will result in employed persons receiving scientific and technical training. Where persons now employed possess the aptitudes for such training, methods must be developed which will result in utilizing what will otherwise remain a hidden source of potential scientific and technical man power. I appeal to our educational institutions and to administrators in Government and industry to take every available measure to help alleviate the shortage of scientific and technical personnel. This must be done if our defense program is to succeed."

† Such a service has been under consideration at M.I.T., and after more than a year of careful study is now in effective operation, as stated on page 200 of this issue of The Technology Review.

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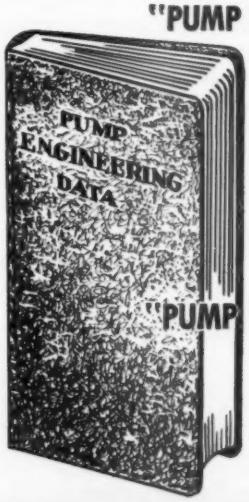

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TRANSPORT HELICOPTERS

(*Continued from page 194*)

is an interim answer, for it is quite clear that in the long run the short-haul traffic will belong to the helicopters, not the fixed-wing airplanes.

The average length of haul per passenger on the trunk lines is well over 400 miles, and it is the market for trips of less than 180 miles which the air lines have been unable to penetrate to any appreciable extent.[91] Yet, this is the field where the advantages of the helicopter are most evident. In such relatively short hops, from city center to city center, the slower speed of the helicopter is more than compensated for by the fact that it is not necessary to begin and end the air journey at airports far from the center of town.

The local service or "feeder" air lines, as they used to be called, already have their eyes on the new helicopters as being equipment holding real promise in meeting their requirements. Even with today's 10- and 12-place machines, such local service is completely practical, and when the 20-, 30-, and 40-place passenger machines now in the development stage come on the market, such services between the centers of large cities within reasonable range of each other become practically inevitable. In a recent article in the *Aeronautical Engineering Review*,[91] Charles Froesch, then Chief Engineer, now Vice-president, for Eastern Air Lines, demonstrated that, for points up to 180 miles apart, the over-all downtown-to-downtown time for a helicopter is less than that for an air-line traveler and that, while the over-all cost to the air-line passenger is $0.07 to $0.095 cents per mile, the direct flight costs on a 25- to 30-passenger helicopter could be as low as $0.045 cents per seat-mile. Local service by helicopter is clearly coming.

Jet Transport Complements Helicopter

Coincident with the gain in favor by the helicopter, because of its slow speed and ability to hover and land almost anywhere, another new aircraft, the jet transport, is also gaining favor because it is endowed with precisely the opposite attributes. These two new developments are destined to complement each other. As the new jet transports go into service at speeds of 400, 500, or 600 miles an hour, almost inevitably they will require very large airports even farther from the centers of cities than the present ones. Also, almost inevitably, they will be nonstop or limited-stop flights, for only such flights would be economical at such high

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speeds. In bringing the passengers to and from these distant jet airports, the helicopter local service operator will complete the new picture of rapid transportation all the way by air. It is fortunate that two such distinct and radical developments in air transportation, appearing on the horizon at the same time, should complement each other so well.

Policy of Federal Government toward Commercial Development of Transport Helicopters

The Federal Government has taken steps to encourage the development of the transport helicopter in civilian uses. It has formulated a commendable policy calculated to support and encourage the development of the transport helicopter (seven passengers and larger).

To the Post Office Department goes the credit for sparking the study to determine this policy. Late in 1950 the Department requested the Air Coordinating Committee† to undertake such a study. It has been completed. As a result of the study, the Air Coordinating Committee has issued a report (59 pages, including appendixes), dated July 19, 1951, unanimously agreed to by the members of the Committee, entitled "Federal Policy Regarding the Development of Commercial Transport Helicopters." It is an excellent and statesmanlike report.‡

In addition to its extensive analytical sections, the report contains conclusions and recommendations. Conclusion Number 10 states in general terms the strong backing of the Air Coordinating Committee as follows:

(*Continued on page 208*)

† The Air Coordinating Committee is composed of the Under Secretary of State, the Under Secretary of the Air Force, the Under Secretary of the Navy, the Under Secretary of the Treasury, the Assistant Postmaster General, the Assistant Secretary of Commerce, the Chairman of the Civil Aeronautics Board, and the Assistant Director in Charge of the Fiscal Division of the Bureau of the Budget (nonvoting).

‡ The report is frequently referred to as the "Waldo Report" because of the fact that the chairman of the Helicopter Working Group, established by the Economic Division of the Air Coordinating Committee, undertaking the study was Richard K. Waldo, who was loaned for the purpose by the Civil Aeronautics Administration of the Department of Commerce. Other members of the Helicopter Working Group were: Burdell L. Springer of the Department of Commerce; Captain Francis D. Foley and Commander M. C. Peters of the Department of the Navy; and Colonel Richard W. Bonnaville and H. Heinrich Spang of the Department of the Air Force.

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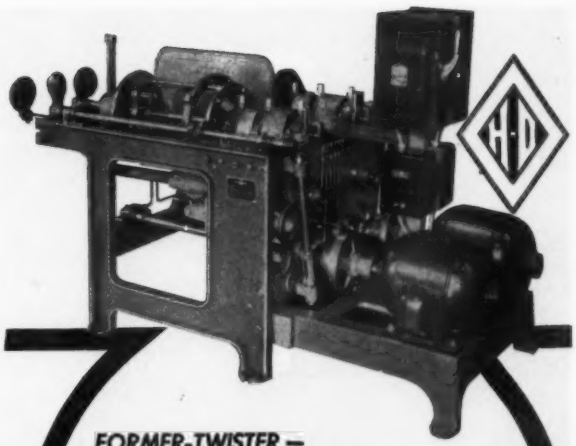

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TRANSPORT HELICOPTERS

(*Continued from page 207*)

The present and potential value of the helicopter to the commerce of the United States, the postal service, and the national and civil defense clearly justifies the continuation and acceleration of the government's policy of support and encouragement of helicopter development and utilization.

The recommendations are specific to the Post Office Department, the Civil Aeronautics Board, the Civil Aeronautics Administration, the Department of Defense, and the National Advisory Committee for Aeronautics. Taken collectively these recommendations spell out a strong and aggressive policy of Federal Government support for the development of civilian-used transport helicopters. Probably in no other field of civilian commercial activity has there been a more timely and constructive policy developed for future use at exactly the moment when it was most needed.

Cost Considerations

None of these dreams will come true, however, unless the cost of buying and operating the big, new helicopters is such that the price of transportation is one which the passenger or shipper can afford to pay. This naturally breaks down into capital cost and operating cost.

No transport helicopters have yet been delivered on the commercial market or to other than the military services. Consequently, the market price of these machines has not yet been established. Based on the cost of production of the military models, however, it is possible to estimate the range of probable commercial sales prices. Based on its knowledge of the subject, the Helicopter Council of the Aircraft Industries Association, made up of the leading helicopter manufacturers, has estimated some time ago that the price of a 10-place helicopter will be somewhere between $120,000 and $150,000.[92] Assuming the higher of these two figures, the cost per seat would be less than that for the Constellation or Stratocruiser and equal to that for the DC-6.[93] It is thus apparent that, considering the cost of the aircraft alone, the helicopter will be competitive in price with the fixed-wing aircraft.

(*Continued on page 210*)

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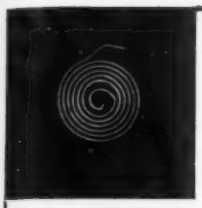

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TRANSPORT HELICOPTERS

(*Continued from page 208*)

Two other factors must also be considered in this connection however. The first is that the helicopter requires only a very small landing area, with relatively inexpensive improvements, as a heliport.§

Secondly, the fact that the helicopter does not require the fabricating of large, thin sections necessitating much handwork and extensive plant area, as does the fixed-wing plane, and the fact that such specialized helicopter components as the transmission and rotor head are susceptible of machine manufacturing methods, render the helicopter much better adapted to quantity or mass production than the fixed-wing airplane.[93] Since the estimated prices quoted above are for machines at a relatively low rate of production, the effect on original cost of putting them into quantity production will be such as to make the cost picture more favorable.

Direct costs of operation in commercial service must also be estimates for these larger machines, of course, since no one has operated them commercially. Some authoritative estimates, which at least indicate the trend, have been made, however. In the *Los Angeles Renewal Case*, referred to above, the Piasecki Company estimated that a machine of its HRP type, fitted with high-density seating for 21 passengers, could be operated over the routes proposed in the *New York Case* for $0.032 per seat-mile. This is comparable to a DC-3 and was based on an assumed first cost for the machine itself of $180,000 and a weight of 170 pounds per passenger.[94] As was pointed out above, a seat-mile direct operating cost of $0.045 for a machine carrying 25 to 30 passengers is estimated. When the 25-30 passenger machines now under development come on the market, the cost per seat-mile will go down even further.

These cost estimates and forecasts were carefully studied by the Air Coordinating Committee in the Waldo Report referred to above. The Waldo Report points out that the Department of Defense today has production contracts for four types of transport heli-

(*Continued on page 212*)

§ In fact, in the *New York Case* one of the applicants proposed that heliports in suburban communities be combined in some cases with centrally located gasoline service stations, thereby providing mutual benefits for the community, the helicopter operator, and the gas station operator.

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TRANSPORT HELICOPTERS

(*Continued from page 210*)

copters (and development contracts for five more) with five different manufacturers which, as commercial models, would range in capacity from seven to 44 passengers plus mail and cargo, with one model capable of carrying 70 passengers. Under certain assumed operating conditions, the Waldo Report estimates a direct operating cost per ton-mile of transport helicopters to be from about $1.00 to as low as $0.33 to $0.35. The costs decrease with increasing size and work capacity, with the cost curve flattening out, at the present state of the art, at the 20- to 30-passenger size. With subsequent experimentation, operating costs may slide in the direction of the $0.22 per ton-mile cost for the DC-3 aircraft.[95, 96] Such a cost picture means that the helicopter will ultimately be capable of making substantial inroads into the mass short-haul travel market represented by passenger trips of less than 200 miles, and that it will create new short-haul business in this area. Furthermore, such helicopter travel would tend to be more competitive than the airplane, economics-wise, with the automobile, train, and bus transportation.

The twin industries of helicopter manufacture and helicopter operation (scheduled, nonscheduled, fixed-based, contract, or what-you-will,) which bid fair to effect something of a revolution in transportation, and to become an accepted instrument in agriculture, industry, and commerce, look like good places for a young man.

The author wishes to acknowledge with thanks the valuable services of Brackley Shaw, and of James F. Bell in the preparation of this article.

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[62] "Leading Helicopters of the U.S.," *Aviation Week,* page 84, February 26, 1951.

[63] "Development of the McDonnell XHJD-1," *American Helicopter,* July, 1950.

[64] "Statement of F. N. Piasecki," Exhibit PC-2, *Los Angeles Certificate Renewal Case,* C.A.B. Docket No. 3800.

[65] *American Helicopter,* VII: 4, No. 8 (July, 1947).

[66] "Statement Before the Civil Aeronautics Board in the New York City Helicopter Service Case by Bell Aircraft Corporation Concerning Bell Feeder-Liner Helicopters," February 6, 1950.

[67] "Testimony of Sikorsky Aircraft Division of United Aircraft Corporation," Exhibit PC-4 in the *New York City Area Helicopter Service Case,* C.A.B. Docket No. 946, *et al.,* February 6, 1950.

[68] "Helicopter Value Recognized by Military," *Aviation Week,* February 26, 1951.

[69] Berry, M., "Bell Anti-Submarine XHSL-1," *American Helicopter,* XXI: 10, No. 3 (February, 1951).

[70] For a discussion of the development and future of the large transport helicopter in Great Britain, see the Report of the Interdepartmental Helicopter Committee, appointed by the Minister of Civil Aviation, digested in *Aviation Week,* 54:21, No. 15 (April 9, 1951); Desoutter, Denis, "New British Helicopters," *Aviation Age,* 15:23, No. 5 (May, 1951); reference No. 61 contains some discussion of the French position in this field, too.

[71] An article in *Aviation Age* states that "Russia appears to be far behind both the U.S. and England on the matter of rotating wing aircraft . . ." However, the article also states that Ivan P. Bratukhin "reportedly is in production now with a 16-24 place machine." "Russia's Designers," *Aviation Age,* page 25 (July, 1951).

[72] Testimony of F. N. Piasecki, I. Sikorsky, and E. E. Gustafson (Bell Aircraft) in the *Los Angeles Certificate Renewal Case,* C.A.B. Docket No. 3800, Tr. 23-26, 44-46, and 58-59.

[73] See exhibits of leading helicopter manufacturers submitted in the *New York City Area Helicopter Service Case,* C.A.B. Docket No. 946, *et al.,* as PC-4, page 2; PC-5, page 12; PC-6, page 2.

[74] Gill Robb Wilson in the New York *Herald Tribune,* December 12, 1950.

[75] Exhibit PC-1, *Los Angeles Renewal Case,* C.A.B. Docket No. 3800.

[76] *Times Herald,* XIII:1, No. 232 (September 20, 1951).

[77] *Marine Corps Schools,* published at Quantico, Va., 1951.

(*Concluded on page 214*)

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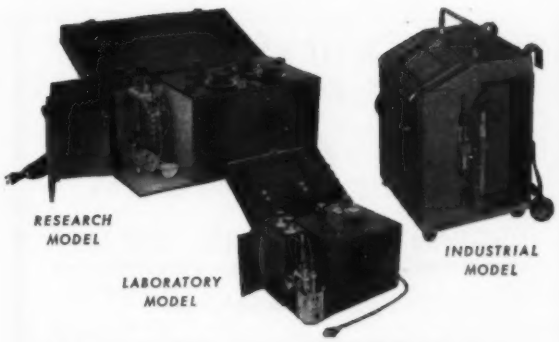

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(*Concluded from page 213*)

[78] Letter dated February 2, 1950, from Colonel K. M. Landon, Deputy Chief of Staff, Armed Forces Special Weapons Project, to Admiral D. C. Ramsey, President, Aircraft Industries Association, submitted in *New York City Area Helicopter Service Case,* C.A.B. Docket No. 946, *et al.,* Tr. 34, 35.

[79] Letter dated February 16, 1950, from Major General Robert M. Webster to Fred M. Glass, Director of Airport Development, Port of New York Authority, submitted in *New York City Area Helicopter Service Case,* C.A.B. Docket No. 946, *et al.,* by the Port of New York Authority as Exhibit No. 27.

[80] For a discussion of the effect the large military orders have had on the helicopter industry, see "Helicopters Again — Rescue Jobs in Korea Boom Military Demand for 'Flying Windmills,'" *Wall Street Journal,* January 5, 1951.

[81] *The New York City Area Helicopter Service Case,* C.A.B. Docket No. 946, *et al.*

[82] *Los Angeles Certificate Renewal Case,* C.A.B. Docket No. 3800, decided July 5, 1951.

[83] "Report of Examiner," page 11, *Los Angeles Airways Certificate Renewal Case,* Docket No. 3800, served March 23, 1951.

[84] "Statement of Fred M. Glass," Director of Airport Development, Port of New York Authority, in the *New York Case,* C.A.B. Docket No. 946, *et al.*

[85] Coleman, Frank, "Automatic Pilots for Helicopters," *American Helicopter,* **XXI**:11, No. 3 (February, 1951).

[86] Exhibit PC-1, *Los Angeles Renewal Case,* page 3, C.A.B. Docket No. 3800.

[87] *Wall Street Journal,* January 30, 1951.

[88] *Aviation Week,* page 17, November 20, 1950.

[89] For a discussion of the development of autopilot and the engineering principles involved, see Meyers, D. N. and Vanderlip, E. G., "Helicopter Stability via Automatic Control," *Aero Digest,* **62**:17, No. 6 (June, 1951).

[90] Transcript of Hearing in the *New York Case,* pages 741-743, C.A.B. Docket No. 946, *et al.*

[91] Froesch, Charles, "Looking Ahead with Air Transport," *Aeronautical Engineering Review,* May, 1950.

[92] "A Survey of Progress in the Development of Helicopters and Their Uses," page 13. See reference No. 61.

[93] "A Survey of Progress in the Development of Helicopters and Their Uses," page 43. See reference No. 61.

[94] "Statement of F. N. Piasecki," page 14. See reference No. 64.

[95] "Federal Policy Regarding the Development of Commercial Transport Helicopters," Air Coordinating Committee (July 19, 1951), pages 16-21.

[96] Waldo, "Economic Prospects for Large Transport Helicopters," *Proceedings of the Seventh Annual Forum of the American Helicopter Society in Cooperation with the Institute of Aeronautical Sciences,* April 27, 1951 (New York: Institute of the Aeronautical Sciences), $5.50.

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November, 1951

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In many respects the propulsion of aircraft is an ideal use for nuclear energy. Here, to a higher extent than in any other application, the advantages of a highly concentrated source of heat can be used to good result. Although the goal of producing a nuclear powered aircraft is an admittedly ambitious one, it is only such high-performance, premium uses of energy which can today justify the consumption of as rare a resource as uranium-235 or plutonium-239. Moreover, it is inescapable that a development of this type has great military significance.

In recent months the government has announced that the nuclear aircraft program is entering a new phase. In this new phase, the Aircraft Gas Turbine Department of the General Electric Company has been given the responsibility for the propulsion system, and the Consolidated Vultee Aircraft Corporation is to supply an airframe.

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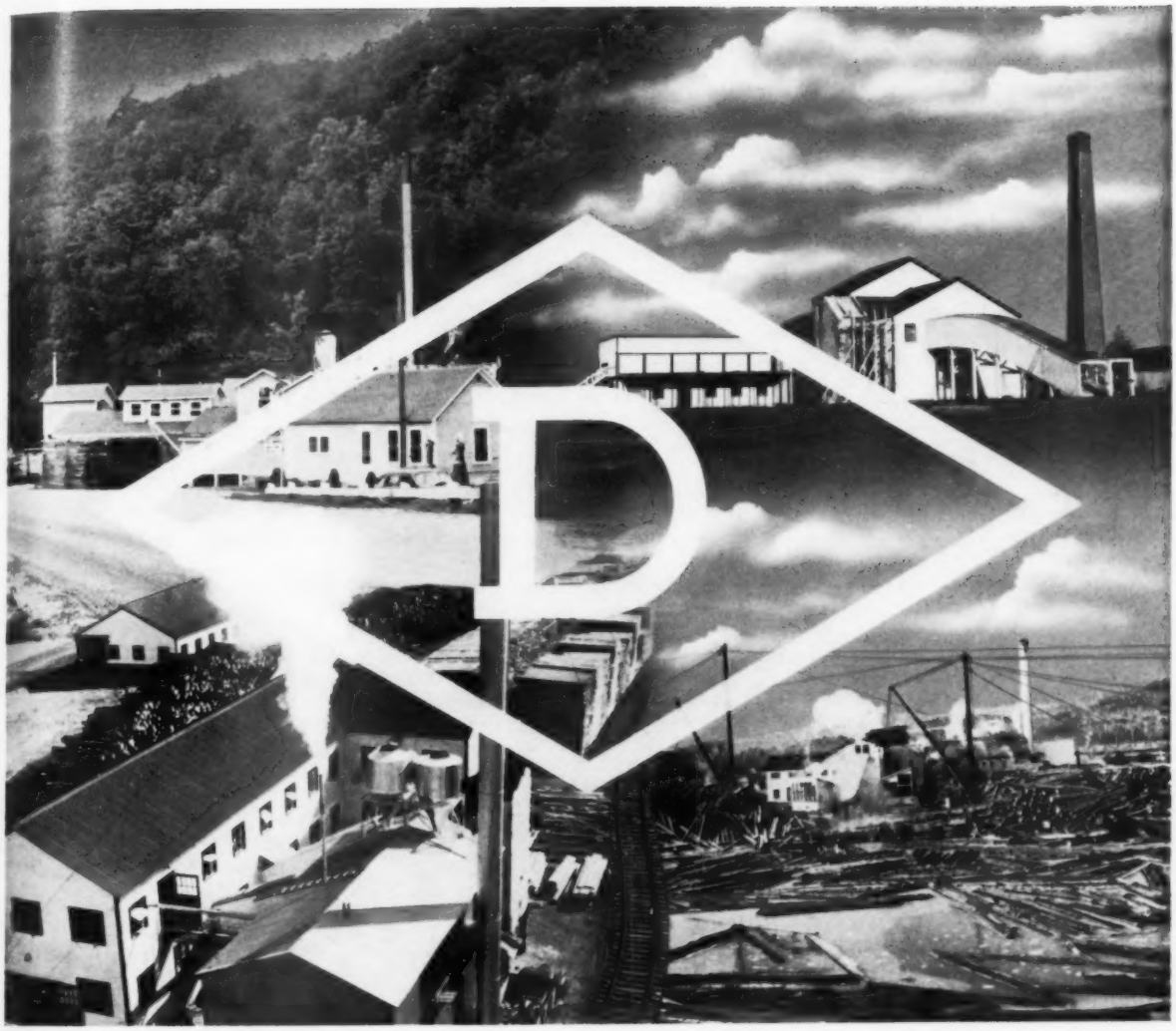

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